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Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

PUMPING ENGINES No. 3. (Continued.)

(Continued from Vol. xliv, p. 373.)

ENGINES.—The engines, as the second subdivision of our subject, may be specified in two general classes; the *single-acting*, or those which take steam in one direction for each double stroke, being returned by a counterweight; and the *double-acting*, or those which take steam in both directions.

Single-acting engines have vertical cylinders with the pumps beneath them, or beams, with the pumps under the outer end centres, the latter being the rule, the former, the exception.

Double-acting engines may be vertical, inclined, or horizontal, with direct or with crank motions. Direct double-acting engines operate with and without beams (or half beams), the latter being the exceptions, and double-acting crank engines, operate with and without beams, the latter being the exceptions.

Single-acting Engines.—In the single-acting mining engines, with beams, the steam stroke makes the suction lift of the several plunger pumps attached to the pump-shaft, and the suction and force lift of the lower bucket pump, the chief pumping stroke being made with the steam piston *in equilibrio*, by the weight of the descending pump shaft and attachments. In the water works engines, but one plunger

pump is generally used, attached to a counterweight, the downward steam stroke making the suction lift. In the "Bull" engines, or those which act without beams, the steam stroke is upward, and also makes the suction lift. But in the Haarlem Meer single-acting beam engines with annular cylinders, the counterweight is lifted on the full steam stroke, the pumping lift being made on the return expansion stroke. These engines are therefore double-acting as to the cylinders in one sense, though entirely single-acting as to the several pumps, and as to distinct piston motion.

The engines of this general class, from their prominent rank, require somewhat particular notice, in which those used at the mines will illustrate the leading principles of operation, the water works engines being modifications of the same type. This notice will include their introduction, general and detail arrangement, and performance.

Introduction.—Watt erected his first engine in Cornwall, as an improvement on the engines of Smeaton, Hornblower, Newcomen, and Savery, about 1776, the first steam mining engine having been built about 1713. His prominent improvements included the condenser and air-pump, the expansion gear, the parallel motion, and the steam-jacket, with an improved workmanship and arrangement of details and arrangement of boilers, and have not been much modified since his day. About 1835, Thomas Wicksteed, Esq., Engineer of the East London Water Works Co., advocated the use of the Cornish Engine, and in 1837 the engine at the East Cornwall mines, near Callington, was taken down, altered, and re-erected at Old Ford for the Company. This was the first application of the single-acting beam engine to water works, an example extensively followed since that time. About 1790 several "Bull" engines were introduced in Cornwall, in which the cylinders were placed directly over the pump shafts.

General Arrangement.—In general, the boilers are placed in a separate house, connected with the engine house wall, and at a level below the cylinder base, for convenience in coal delivery, in taking steam, and working the steam jacket. The cylinder is housed in from the beam-centre, of which the supporting wall sustains the main pillow blocks, the air pump, condenser, and pump shaft being uncovered. In making the steam stroke, the engine is therefore said to "go in the house," in mining parlance. The cylinder foundation of solid stone work is built up several feet above the ordinary grade. The side pipes and valve gear are placed between the cylinder and main centre so as to be worked by a plug rod from the beam. Great care is taken to enclose the steam pipes and cylinder with various devices to prevent radiation and condensation.

The peculiarities of the *cylinder* are the precautions for maintaining its heat by the steam-jacket, and by air spaces, brick-work, plastering, and lagging, in part or wholly used in addition. The steam-jacket is supplied by a special steam-pipe, and returns its condensed water to the boilers by gravitation. Its chief value is to prevent radiation and to compensate the effects of sudden changes of temperature from those of pressure in expanding, and the continued use of full steam at

the upper end only; for low grades of expansion its value is less apparent. The cover is made double and filled in with some non-conductor; the bottom also is double and supplied with steam, a practice which in the latter case is held objectionable in some instances from its effect on the exhaust. The stuffing-box has a steam packing chamber fed from the jacket to prevent the admission of air during the minus pressure in the cylinder at certain parts of the stroke, an ingenious and important arrangement. The piston-rod is so attached to the cross-head as to be free from it in one direction, in case the steam stroke from any accidental cause should charge the weighted beam with extraordinary momentum, which the spring beams might fail to sustain. These beams are placed above the cylinder so as to terminate the stroke in either direction when the piston does not itself come to its usual rest, catch-pins being placed on the beam for this purpose; a precaution of this kind is advisable, since the end centres or terminii of the stroke, are not controlled by a crank; but these engines admit so delicate an adjustment in operation, that the spring beams are safeguards rather than indispensable working parts to each stroke.

The *beam* is generally cast in two plates, bolted together with stud-blocks. Parallel rods are used for guides. It is generally centred so as to reduce the pump velocity in the ratio of 10 (piston) to 8 (pump). The improvements in forging and an assumption of increased safety, have induced the introduction of wrought iron beams, but in this case the large excess of weight used in these beams is overlooked, an excess of great consequence in engine inertia and momentum, which cannot be properly dispensed with.

The *valve motion* is controlled by a single or double plug-rod, from the beam, which is provided with tappets to operate the valve levers, and the cataract lever. The cataract is a very simple and beautiful arrangement by which a small weighted pump plunger, when lifted by the rod, is regulated in its time of descent by throttling its discharge orifice, and opens the exhaust and steam valves for the return stroke by means of certain rods, levers, and cams, at a given point, thereby determining the number of strokes in a given time. This motion, as a whole, is effective and easily adjustable, but somewhat cumbrous and noisy, and is necessarily automatic, from the absence of eccentrics and rotary motions.

Four valves are used, all of which are of the double-beat or balanced form, viz: the governor valve which throttles the admission of steam to the steam chest, and works close to the steam-valve so as to prevent any material collection of steam at full pressure, between them; the steam-valve, which operates in the usual way; the exhaust valve, which opens in advance of the steam-valve at the base of the cylinder; and the equilibrium valve, which provides for the counter-weight return stroke by connecting the lower side of the piston with the upper, so as to produce a balance of pressure. The lap and lead given this valve at will regulates the amount of cushion for the upper and lower piston stroke.

The double beat valve was introduced by Hornblower about 1800, and exerts an essential influence on the operation of the valve gear. The proportions of the steam and exhaust valves are also of great consequence, the former being made about one-fifth and the latter about one-fourth of the cylinder diameter, the pipes being suitably enlarged.

The *condenser and air-pump* are about equal in size, the latter having half the engine stroke, and nearly half the cylinder bore. With its connexions the condenser is about one-third the cylinder contents. In working, the injection is intermittent, being let on and closed with the exhaust, and the "hark" or pause between each stroke is claimed as an advantage to the vacuum. The air-pump, in addition to its foot-valve, has a floating cover as a delivery valve.

The *counterweight* is represented in these engines by the pump-rods and attachments which frequently have inclined lines of motion, and by the use of balance beams and bobs. A weight equivalent to the main pump load and all its frictions is, therefore, put in motion on the steam stroke, as the agent of the return stroke, as is also the case in the Bull engines, and in a less complicated manner in the water works engines. This stroke is therefore controlled and assisted by the inertia and momentum of these weights of the suction columns, and of the lower lift, (noticed under the appropriate head.)

In general arrangement, then, the salient points of the single-acting engine are found in its guards against radiation, condensation, and leakage; its simple and direct motions which reduce friction; its large valve openings, balanced valves, and automatic valve-gear; its condensing apparatus; its weight in motion; and its careful workmanship.

Performance.—In operation the engine has these characteristics, —that all its motions are natural and deliberate, harmonizing with its work, both on the steam and equilbrium stroke; that the upper steam cushion is not wasted in power; that high initial pressure and moderate throttling is used, since the inertia of the mass to be overcome, and the time for transmission of impulse freely permit such initial force; that the subsequent *vis viva* of this mass, admits and requires a high range of expansion to prevent waste of power and concussions at the stroke-end; it is also, claimed as an advantage that the piston is independent of the pump column, and does not control its speed, although the experience of the Huelgoat, Haarlem Meer, Brooklyn, and other engines does not substantiate the claim, as a beneficial principle of action. In performance these engines, in use so many years and in large numbers, and of very large sizes, take rank of all others in mining and water works on record. While their average duty is itself far in advance of that of other classes, individual cases range up to a formidable proportion, as we shall have occasion to show in the proper place.

A reference to the single-acting engine is important not only from its rank among pumping engines, but from its position in relation to all other steam engines. The successful development of its principles

of action, underlies all others, and it is impossible to analyze one class independently of the other. The history of the Cornish engine is the history of the steam engine, however varied in arrangement, and one must be diligently studied to comprehend the various divisions of the other, since both are controlled by the same laws of maximum useful effect. This engine is then the true standard, as it is the pioneer also, of all others.

And from this basis of examination it is an interesting study to trace out the various ways in which these several principles of action, are vindicated amid seeming mechanical contradictions. Nothing apparently could be more dissimilar from this standard than a Mississippi engine coughing out steam at 180 and 200 pounds pressure, with its rude expansion gear, and yet it was in Cornwall that the economy of high steam was asserted and demonstrated through numerous trials, as well as the economy of expansion; if then, in Cornwall, it was shown that for a given range of pressure the condenser was an economy, the western waters have continued the demonstration of economy in connexion with convenience by increase of pressure, and rejection of the condenser, simply showing a point where the advantages of condensation may be superseded by increased advantage in manufacture of steam and questions of space. It may be held that the ordinary crank and fly-wheel engine is of a different class, but it agrees as to the admitted use of non-conductors, of balanced valves, of high pressure and expansion, of condensation, of weight in motion, differing chiefly in the arbitrary control of the piston exercised by the crank in reducing a certain reciprocating to rotary motion, and in the detail of valve-motion. Between the counterweight and the fly-wheel there is no difference in principle of action, as each has its distinct work to perform for each stroke. Certain necessities of application require a departure from the simple Cornish motion in various ways, as in combined and horizontal and geared rotary engines, &c., but the standard is never left without a loss in effect. In matters of detail the arrangement of vertical beam engines, the Americanism of balanced puppet valves, the parallel motions, floating air pump covers, boiler feed pumps, injection stands, piston form and packing, and other parts in common practice with us, may be traced directly back to these past generations of experimental research, which in some particulars of this kind may yet be studied and copied with advantage.

That diversity of mechanical form may be consistent with mechanical principle, or in other words, that principles are superior to forms adapted to them, is also, a matter of interesting research. The principle of non-conductors around steam vessels, does not necessarily involve the use of steam jackets, if by superheating or perfect clothing, the same useful effects may be obtained, and some inherent mechanical objections avoided; nor is the use of such devices peculiar to the single-acting engines which introduced them. This is true also, of perfect valve arrangement, and proportion of condenser and air-pump; of pressure and expansion; of inertia and *vis viva*, which may be equally useful and effective in double-acting engines. The supre-

macy of principle being recognised, the subordinate questions of application become special and local, and what is chiefly important is, that principle should always take rank of detail.

The history of the Cornish engine is important in another respect, viz: in the examples it presents of various experimental devices, as modifications or assumed improvements of this standard. The Bull engine was an attempt at increased simplicity in one respect and to avoid a patent in another; it fails however, from its imperfect application of the *vis viva*, and its consequent defects in taking steam and expansion. Hornblower, Wolfe, and Simms in their school, attempting an improvement in the method of expansion and steam travel by combined full steam and expansion cylinders, in which the pressures sometimes were varied as high as twenty to one, overlooked the law of inertia and *vis viva*, and encountered counteractions and serious frictional losses; so also, in the Boulton and Watt, and the various other forms of engines offered as substitutes, a formidable chapter of experiment demonstrates the value of correct, harmonious principle, for the instruction of all who choose to heed it.

Double-Acting Engines.—But engineers who comprehend and respect this supremacy of natural law, have also been impressed with the advantages which result from its application to double-acting pumping engines. The single-acting cylinder is open to these objections, as compared with the other,—that it must be not less than twice the size requisite for the same work in its proportions and appurtenances; that the beam and its bearings must sustain not less than twice the load; that the risks and effects of accidents, and the frictions are proportionally increased; that the air-chamber and some other parts must be doubly larger and stronger; that the outlay in capital is much greater, and in annual expense, also, to a certain extent; that the momentum of a weighted and balanced beam is preferable to that of a counterweighted beam, as to losses in excess of initial pressure and adjustments; that the *vis viva* of the force-lift pump column is lost to the steam stroke; and that the elastic steam stroke is better adapted for pumping than the non-elastic counterweight, and produces a better result with much higher and more controllable speed. And it has been reserved for an American engine, which ranks all other pumping engines in actual power, to demonstrate the correctness of adaptations of principle to this modification of form.

If, however, we examine the pumping engines of this country, which are double-acting as a class, in view of the principles enunciated, we find them at fault in several particulars. And first, in their general arrangement, as to the use of the crank.

Crank Motion.—It must be admitted without much study, that no change can be made from a reciprocal to a rotary motion, without doing violence to the conditions of motion, and it is also evident from a simple analysis, that the natural movement of a steam piston is inconsistent with the uniform revolution of a wheel or crank, on account of the relative spaces passed in a given time, and the relative variations of pressure and resistance due to each. We refer now to fric-

tional and counteractive losses of power and not to the fallacy of any inherent loss of pressure.

In the elaborate theoretical demonstrations of crank motion which have been made from time to time, it will be observed that the element of mass in motion is neglected, but what is proper for a certain analytical purpose is not to be assumed correct for an investigation of useful effect, since such an element is indispensable to all engines in greater or less proportions. What, then, we have by pump cards, shown to be true of a mobile liquid, in its laws of initial and final motion, certainly cannot be less true of any homogeneous mass of metal, or of the working parts and load of any crank engine; and it is inevitable that there must be a certain initial and surplus impulse imparted to the mass which is felt throughout the stroke, and is compensated by its *vis viva*. After the time occupied in charging the load with this impulse, and from the time the impulse is properly communicated and has produced a maximum velocity, the natural law of piston motion involves a gradual reduction of speed. But the tendency of the crank and fly-wheel is towards uniform speed, and if this could be attained in practice, the piston would vary in speed in a manner entirely incompatible with its legitimate impulse or travel, being retarded where it ought to accelerate, and accelerated where it ought not to be. Hence result severe counteractions and frictions, which tend to reduce useful effect and embarrass proper operation. On one of the most carefully constructed crank engines, we have ever seen tested as to this loss, 23 per cent. was the lowest rate, as compared with the ordinary Cornish result of 10 per cent. and the Brooklyn engine of 7·4 per cent., while in the ordinary cases in practice, the loss easily reaches a much more serious effect from differences in workmanship. We may take it for granted then, that the use of the crank is to be avoided in all cases where the work permits it, and particularly in all pumping engines, from its arbitrary control of natural piston and pump motion without any compensating benefit. The idea that the terminal stroke and valve-motion may not be fully controlled without it is a mechanical error.

Radiation.—The general neglect of non-conducting protections for the cylinder and steam-pipes, has an injurious effect on engine duty. While a somewhat quixotic stress has been occasionally laid on cylinder condensation, without corresponding stress on radiation and their preventives, the lessons of correct practice require the proper application of the latter in the most simple and effective way. As to steam-jackets, we believe the Brooklyn engines are the only double-acting pumping engines in the country which use them, and as to the more ready application of felting, and other covering, there is a manifest room for improvement, which will quickly vindicate its value in useful effect.

Valves.—The use of balanced puppet valves is correct in principle, while slide valves are generally objectionable, from restricted openings, and increased valve load; nor can the importance of large openings be too strongly urged. Even with locomotive cylinders,

which are necessarily small and used under high pressure, the best practice requires an opening of the full diameter of the piston, and what is true in principle in such a case, is equally applicable to larger cylinders under much less pressure. The severe losses in back-pressure to all cylinders are generally due to restricted exhaust. The losses of steam in the chests and clearance are frequently formidable, and deserve a careful attention. Those engine builders who bring their valves as close as possible to the cylinder ports, find by experience a benefit which is of great consequence. One important reason why long stroke engines are more economical and effective than the short stroke, is explained by the less frequent change of centres and corresponding savings in the clearance and steam chest. As to the working parts of the valve motion, it is a matter of little consequence to the cylinder how they are arranged, and they should be as simple and convenient as possible; "lap" and "lead" are of much greater consequence, and should be carefully adjusted by reference to indicator cards to the maximum effect. There are numerous varieties of expansion gear in use, which illustrate the difference between ingenuity and judgment, and are of unimportant choice, so that the steam-valve shuts at the proper moment, and its time of closing is adjustable conveniently.

Condensation.—The relative location, size, and arrangement of the condenser and air-pump, exert an important influence on their office. The vacuum formed by condensation is more or less imperfect from the percentage of air in the injection water, from uncondensed vapor, and imperceptible leakages; the friction of the exhaust passage may also increase back pressure; and a neglect of proportion in the air-pump may add a useless load to the engine, counteractive of effect. These parts should therefore be carefully adapted to their actual work, in proportion and workmanship, with regard to the precise office of each.

Problem of Useful Effect.—In pumping-engines which are built to perform certain known work, and in which capacity is determined by size and speed, the problem of maximum useful effect may be adjusted from the pressure, expansion, and momentum, forming the important triad which controls it.

High Steam.—As to the manufacture of steam, it is a matter of simple demonstration, which may be omitted here, that it is cheaper to make it in a ratio progressive with its pressure, from the law of pressure and density, the standards of boiler radiation and other losses, the increased absorption of heat by water, and other natural and mechanical causes; but in ordinary boiler practice, and particularly in condensing engines, there is a limit to pressure, which seems to be established by common consent, considerably below 100 pounds, (plus pressure.) In fact, the Cornish practice, from 45 to 75 pounds, is considered high in our pumping practice, and is erroneously rejected, except in the Western high pressure non-condensing engines. There can be no question of the superior economy of the Cornish process, which indicates a lesson to be followed in that respect.

Momentum.—With a given average pressure to provide for a given load, and proper initial pressure, which should not be throttled if it can be avoided, (although in badly proportioned engines throttling is much better than low boiler pressure,) the ratio of expansion acting in connexion with the weight to be put in motion, assumes its proper rank in this problem of effect. Though it is manifest that the same average pressure will balance the same average load, and initial pressure and expansion might therefore be indefinitely increased with increasing gain, the conditions of momentum place a limit to this ratio, and indicate its range of practical usefulness.

Expansion.—The doctrine of maximum effect, depending as it does under these conditions, on engine momentum and expansion, makes it clear that either may be regulated so as to control or facilitate the other, and that the engine mass should be so adjusted, within reasonable limits, as to permit a suitable measure of expansion. To say that an engine works imperfectly from being too light, or to say that engine weight in motion is the true measure of its economy, involves a very deep and important meaning, which theory has demonstrated and practice confirmed for generations, although it is not often put in type. The *rationale* is not complicated;—it is necessary to obtain a given initial impulse in excess of the average resistance, that the moving parts and load should have sufficient inertia to prevent abrupt motion; this inertia, in fact, regulates the range of initial pressure, and when overcome by it, and a certain speed generated, the moment for cutting off is reached, and the reducing piston pressure is compensated by the generated *vis viva*, these jointly completing the stroke. The idea of uniform resistance or uniform pressure on any steam piston, is a mechanical myth, existing only in the abstruse regions of speculation; and in every case where an engine will not take steam without close throttling, or will not cut off short, it may be taken for granted that its proportions are at fault in this respect.

As to the usefulness of expansion, *per se*, which has been called in question, under circumstances amply discussed in former pages of this Journal, it may be said that if no other experience existed than that which the Cornish engine has put on record as to this particular, aside from the testimony of natural laws, and as a mere result in reducing annual expense, the correctness and propriety of its use, up to one-twentieth cut-off, is established beyond peradventure. In scores, and fifties, and hundreds, by tens, twenties, and fifties of years, the mining engines alone furnish proof enough on this subject, to establish a theory against all doubts, and all contradictory demonstrations. Cases of this kind furnish proof of the argument advanced in the outset, that the lessons of the past cannot be safely overlooked or neglected by the present, and that principles always vindicate themselves to the benefit or the cost of humanity.

Combined and Geared Engines.—Having briefly sketched the salient points of single and double acting engines, and their movements, in reference to leading principles, some allusion is due to the

practice which obtains with the latter class, in some cases, of combined movements and transmitted power.

What has been shown in reference to combined pumps on the same force main, as a source of injurious counteractions, is equally applicable in spirit to any attempt to make two or more steam cylinders work exactly in harmony, when coupled to the same shaft or working parts of any kind. So long as resistances, in a steam engine, mainly determine pressure, it is impossible that two or more cylinders, taking steam at different times, and offering different pressures at the same time to a common resistance, should avoid mutual counteractions; one must alternately drag and carry the other, to an extent measured by the condition of each special application; each, in turn, must do more than its proper proportion of the work; and combined cylinders at sea and in locomotives, were introduced for the purpose (among others, of convenience in arrangement, &c.) of keeping the engine off its crank-centre; an idea experience has sufficiently corrected aboard ship, and would also correct on the railway if tested. In all cases of combined cylinders, the power to be exerted by each, must be in excess of its due proportion to the legitimate aggregate work. Beside this plain principle of alternate action, in cases where no attempt is made to develop uniform power, the subdivision of engine work into several cylinders, involves a large increase of loss by clearances, leakage, radiation, friction of piston, valve gear, and other working parts, for no good reason whatever, in the attempt at uniform pumping speed, which is itself a demonstrated fallacy.

Without pausing here to specify cases in illustration, as we are now discussing generalities rather than details, it may be said in reference to all geared engines, and other means of power-transmission between the steam and pump pistons, which depart from the simple arrangement of the Cornish engine, that they are defective precisely in the ratio of increased frictional resistance incurred in each special case, as also in quietness of action and other particulars.

And of this point in general it may be asserted, that as an attempt to alter the pumping motions of the standard engine, or to obtain double action at the expense of power, or to modify in any respect the salient features of the master type, for unimportant or subordinate conveniences, they are evidently open to serious objection, and prove it in their records of duty.

Summary.—Taking the single-acting engine as the standard of example and comparison, from its rank as to age, arrangement, and performance, in such manner as an article of this kind will permit, we have endeavored to present as a matter of principle for universal application, and independent of special and local demands, those peculiarities of its operation which seem to be most worthy of general adoption, and are defined by protection from power-waste, directness of motion, perfection of detail and workmanship, pressure, expansion, inertia, and condensation. The several points involved in this group of characteristics have been so presented in contrast or connexion with our diversified school of engines, and with double-acting

engines generally, as to furnish some pertinent basis of judgment on their merits in special cases, under the light of general rules.

Keeping the chapter of engines distinct from that of pumps, we have also avoided here any discussion of special illustrative examples, since the application may be easily made to each or all, and is not immediately involved under this investigation. In some future remarks on engine duty, special applications may be more properly made.

It may be also said, that the low standard of results in some examples of the Cornish school, are simply proofs of their failure, in some respect or other, in proper development of their inherent principles of action, and may be properly charged to incorrect design, construction, or management. This is a case where principles must be held independent of individual results, by which they are negatively vindicated.

(To be Continued.)

On the Preservation of Stone.

From the Lond. Civ. Eng. and Arch. Jour., Sept., 1862.

In our fourth article on this important subject, we proceed to give, as promised, a digest of the process of Messrs. Bartlett Brothers, Camden Town, for the induration and preservation of stone; first however giving an analysis of the latest patent that has passed the Great Seal having the same object in view. This patent has been taken out by Mr. Herbert Church, and is to a great extent based upon the late discovery of Professor Graham, that of obtaining an *aqueous* solution of silica. We pay all deference to the discovery of such an important chemical fact, and feel deeply interested in the results; but, so far as we are able to judge, the solution is wrongly applied in this particular instance. The materials proposed to be used by Mr. Church are an aqueous solution of silica, or an acid solution of silica, and caustic baryta. Beginning, then, with the aqueous solution of silica, let us mention a few of its peculiarities, and then leave our readers to judge how far it is available for such uses as that we are descanting upon, in a commercial point of view. The primary disqualifications are—1st. That it cannot be retained long in solution, but gelatinizes in a comparatively short space of time. 2d. Any agitation by transit or otherwise at once produces this thickening of the solution; so that in either case, from either cause, it is rendered inutile for any purpose where penetration is essentially necessary. None other than a comparatively limpid and true solution can enter the pores of a stone for any purpose whatever. As to the cost of the solution made by the agency of the dialyzer, it must be considerable, and we cannot yet see how it can be produced at commercial prices, for surely no cost of induration should exceed the difference in price between a soft stone, and one that is hard and possessing the maximum degree of durability.

Before leaving the aqueous solution of silica, we would ask, where-

fore should the potash be withdrawn, when in this alkali we have a valuable adjunct for all combinations with other bases? Let us illustrate our assertion by a well-known fact in nature's operations. Felspar is a compound of silica, potash, and alumina, and forms one of the constituents of our standard of durability, granite, and it requires the action of centuries to reduce this felspar to an inferior condition, yet is this at last accomplished by the removal, by atmospheric influence, of the potash. Hence, may we not infer that the presence of the potash is absolutely necessary? Of course, with that which is over and above the correct equivalent we have not been dealing; but even a slight excess is a matter that requires due consideration, before we could pronounce it in the least degree harmful to the stone. In some stones, indeed, we are prepared to say it certainly is not; and in our last article on this subject we find Messrs. Coombe and Wright providing, by the use of silicate of potash, for any deficiency in the stone of this material; and not only in felspar, but also in the mica of the plutonic rocks do we find a large percentage, of potash, as the following analysis will show:

Felspar.		Mica.	
Silica,	63·74	Silica,	53·75
Alumina,	17·14	Alumina,	24 62
Lime,	3·00	Potash,	21 35
Potash,	13·06	Loss	00 28
Water and loss,	3.06		
	100 00		100 00

Having thus proved the durability of these silicates of alumina to be dependent to a large extent upon the presence of potash, we naturally deduce that the total removal of the potash is a disqualification and hindrance to the combination of the silica with another base.

The second solution proposed is an acid solution of silica; in fact, the very solution from which the former one would be separated by the dialyzer. This solution is made from a silicate of soda or potash neutralized by an acid—say hydrochloric—and is, as the inventor specifies, made decidedly acid. We cannot see any advantage in this solution over the fluo-silica acid, except in price; plainly all the disadvantages of an acid action are there present, and these we have already enumerated when dealing with the fluo-silicic acid process of Messrs. Coombe and Wright. We then come to the baryta; this, says the patentee, must be caustic baryta, used by preference of a temperature as nearly as conveniently to boiling heat. We cannot attempt to remove the prejudices that will at once present themselves against such a caustic solution. Touching the commercial part of the matter, we must however say, that (as fairly acknowledged by the patentee) on the least exposure to the air, it becomes covered with a pellicule of carbonate material; and we might also ask, what substitute for brushes is to be found for manipulation, as all known kinds would, in a few hours, be reduced to a rotten pulp?

Here however we leave the materials: and now for their application

and combination. The patentee purposes, by the application of two solutions separately applied, to produce a mutual decomposition in the pores of the stone of the materials so applied; thus silicate of baryta is said to be deposited. The insuperable objection to the use of two solutions has always been the uncertainty of the proportion in which the separate solutions shall be presented to each other in the stone, and the difficulties arising from the liquid passing that which is already decomposed on the face of the stone to the interior. These difficulties have, to our mind, been always insurmountable; and the patentee seems to have his doubts, when he speaks of the use of vacuo and atmospheric pressure to effect the entrance to a desirable degree of the solutions into the stone. We cannot but look on this patent as identical with that of Mr. F. Ransome, and this is another instance in which we have to advert to the difficulty of obtaining valid and secure patents under the existing state of the patent law, and the necessity that exists for patentees to be well advised in this matter. Were either of these patents worth litigation, we plainly foresee that litigation would take place, to the vexation and damage more or less of both inventors engaged.

Respecting the process of induration by silicate of alumina, referred to in the commencement of this notice, this substance appears to fulfil to an extraordinary extent the requirements that past experience in the matter have shown to be necessary. Silica has ever been known to possess a great affinity for alumina, especially in the presence of an alkali. Fuchs says, "alumina combines with silica to form an insoluble product; thus in the manufacture of water-glass, the quartz should not contain any alumina, and the *insoluble* residue left behind when the mass is dissolved in water is probably owing to the alumina which the glass has taken up from the glass pot." In the same pamphlet by Fuchs we read, "If for instance a burned plate of potters clay, which possesses no particular hardness, and can be easily broken in pieces, is saturated with moderately concentrated water-glass; and if the soaking be repeated when it has become dry, it is rendered so hard that it resists both chemical and mechanical action which is made to bear upon it." Here, then, we have the highest and most incontestible evidence of the affinity of alumina for silica and its enduring results, as far as insolubility is concerned; and looking at the constituents of granite, as given in the analysis of its mica and felspar, we find this enduring material to consist chiefly of silica and alumina, and almost wholly of silica, alumina, and potash; and by a parity of reasoning, a process that will secure the impregnation of stone by these substances, seems to leave little to be desired, so far as its materials are concerned. In the case of a siliceous stone, where lime is altogether absent, we should have an artificial mica deposited in the stone; and where lime is present it would be found entering into combination, and without doubt producing an artificial felspar. The completeness of this process has been already remarked upon; for if the before-mentioned elements did not admit of manipulation in a perfect manner, the whole system would prove but a beautiful theory,

not reducible to practice. An extract from the "Annales des Ponts et Chaussées" will show how far we are corroborated by M. Kuhlmann in our statement, who had already theorized in the matter. Failing in success with the silicate of potash or water-glass *seulement*, he tried hydro-fluo-silicic acid; and then advancing another step, the "Annales" state "lastly, he has obtained excellent results from the fixation of potash in the soft limestones by substituting aluminate of potash for the hydro-fluo-silicic acid, the employment of which he has advocated with a view of forming in the stone a compound *analogous* to mica. He thus replaces mica by felspar, which likewise fixes potash in a state of insolubility. From this also he concludes, that in calcareous stones the presence of alumina alone may explain the fixation of a certain proportion of potash, and ought to remove every fear of any alteration in silicified limestone by the slow action of time."

Now here we undoubtedly have the theory of forming an artificial mica or felspar in the stone by the use of successive applications of silicate of potash and aluminate of potash; but as M. Kuhlmann from that date (1858) to the present time has not carried this system into practice, we deduce, as well as from our own experience, that in practice the application of two solutions in a separate form failed in practical working. To Messrs. Bartlett Brothers, then, are we indebted for the completion of the theoretical systems of both Fuchs and Kuhlmann, inasmuch as they have discovered that in an alkaline menstruum the silica and alumina may be used (with proper limits as to time) as one solution; thus, wherever the one is conveyed the other is present in its due proportion, leaving nothing to chance either concerning the presence of the re-agent or its due proportion. If then saturation of a porous body with the elements of mica or felspar, for which element it has a great affinity, adds to it hardness, durability, and consequent resistance of the injurious effect of time and atmosphere, certainly that is effected in Messrs. Bartlett's process; and whilst we may look upon the "honorable mention" of the jury of Class II. as confirmatory of this opinion, we cannot see why their approbation should have stopped short of the award of a medal for the untiring perseverance and energy that has developed so satisfactory a solution of this important question.

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*The Economic Construction of Girders.**

From the Lond. Civ. Eng. and Arch. Jour., Aug., 1862.

(Continued from vol. xliv. page 384.)

Girders of Great Span.—The most striking peculiarity of a girder of very great span is, that a large portion of its strength is absorbed in supporting its own weight: and were the span extended to a certain point (varying, however, according to the economic merit of its

* Some errors in our last paper were unavoidably left uncorrected. The more important are, page 193, col. 2, line 40, for el read $e:1$.† Page 194, col. 1, line 26, for i'' read *one inch;* line 36, for $\frac{1}{8}$ read $\frac{1}{8}$; line 38, the central formula should have come first; col. 2, line 23, for *net* read *ultimate.*

† Jour. Frank. Ins., vol. xliv. p. 316, 8th line from bottom; p. 318, lines 2d and 4th from top; p. 319, line 4th from top.

particular construction and the quality of the material made use of), the girder would just break down from its own weight, and when this point is reached, by no amount of additional material could this ultimate span be extended while the nature of the structure remained unimproved.

Another peculiarity, the importance of which has never, so far as we are aware, been sufficiently enforced on the attention of engineers, is the immense saving of material and expense that is secured in a great girder by adopting a mode of construction which on the small scale would show only a very moderate percentage of economic merit over another. This is one of the points we shall endeavor, in our next paper, to place in a clear light before the reader, and the results will justify our high estimate of the importance of such investigations as those in some of our previous papers, devoted to the discovery of the most economic designs and arrangements of girders.

The Factors of Safety.—The first question that demands our attention is the proportion which the absolute strength of the structure should bear to the greatest possible stress that may be brought upon it in actual work; or, in other words, the proportion that should exist between the ultimate and working stresses. Great diversity of opinion has been shown upon this point by engineers, but we need not encumber our pages with criticising the ill-judged extremes that have been by some adopted. With regard to the factor of safety for dead weight or still loading, we may almost assume it as a settled matter, that in wrought-iron structures the absolute strength should be about, but not less than, *three* times that which would just withstand the stresses; or, in other words, that the factor of safety should be about 3, not less, and not much more.

It is as to the strength to be provided to withstand a moving load—such as a railway train—that such diversity of opinion exists. The reasons for augmenting the factor for the movable loading above that for the still loading, are—1st, the direct shocks or blows from the wheels on passing over irregularities in the roadway; 2d, the suddenness with which the load is imposed; and 3d, the reaction when the engine rapidly surmounts any sudden rise in the road near the centre of the bridge. Now it will be at once perceived that each of these prejudicial actions becomes rapidly less significant as the span increases, and for long spans may become in a primary form inappreciable, leaving only a vibration throughout the structure, which will heighten to some degree the destructive power of the still as well as of the movable loading. The *first* of the above mentioned prejudicial actions of a rapidly moving load, viz:—that from direct blows of the wheels, may become somewhat serious in very short and light spans, since in such the load on the falling wheel may constitute an important percentage of the whole mass of loading and structure taken together; but in a long span, with the load supported on a great many wheels, and the structure itself of great weight, the effect of only one or two wheels dealing their blows at the same instant, becomes, when considered with

regard to the whole structure, almost inappreciable. The *second* prejudicial action is likewise deserving of attention in very short spans, since in these the engine may come so suddenly upon the centre of the bridge as to act in some degree the part of an instantaneously imposed load, acquiring a certain downward momentum from the flexure of the bridge; as, however, the load is again removed with equal rapidity, too much importance should not be given to this effect, and for the case of any span of importance it may be said to vanish. The *third* or last detrimental action is also almost confined to very short spans; in long spans it is only a very small fraction of the load that could have its effect thus increased at the same instant.*

We will now examine the modes of apportioning the ultimate strength or breaking weight of a structure, as proposed by Professor Rankine and Dr. Fairbairn. The latter gentleman, in a paper read before the British Association in 1861, (see vol. for 1861 of this Journal, p. 329,) speaks as follows:—"For the present I would advise that in all beams and girders, tubular or plain, the permanent load, or weight of the girder and its platform, should not in any case exceed one-fourth of the breaking weight; and that the remaining three-fourths should be reserved to resist the rolling load, in the proportion of 6 to 1." Now the results by this rule are given in columns 3 and 4 of Table I., column 4 giving the *general factor*, or that estimated over the whole loading W, fixed and movable without distinction; and it will be perceived that we have its values arranged in two series, the first a decreasing one, giving a minimum of security when the dead weight becomes double the movable loading; and at this point a new and increasing series begins, which we apprehend could never have been contemplated by Mr. Fairbairn. In the Conway bridge as executed, the dead weight is about three times the greatest movable, and by this table we find the general factor, according to Mr. Fairbairn's rule, to be = 3 for such a case; but had the structure been lighter, say equal to twice the movable loading, Mr. Fairbairn's rule would have given a factor = 2·75, being less instead of greater than for the heavier structure—this, of course, he could not have intended.

Professor Rankine gives the following factors:—for the fixed load, factor of safety = 3; for the movable load, factor of safety = 4 to 6. In the table we have given the results for the general factor, arising from the adoption of values of the latter = 6 and 4·5. It may be pointed out that these factors lead to the same results as though we increased the movable loading to 2 tons and 1·5 tons per foot run respectively, and treated it along with the dead weight.

On comparing the general factors obtained by these methods, particularly for the case of the fixed loading being double the movable, it will be perceived how widely they differ.

* We must call attention to the fact that the transverse girders to support the roadway are peculiarly liable to all the evils that may arise from the mobility of the loading. It comes with excessive suddenness upon them, and is nearly their whole loading; a blow from a pair of engine driving-wheels is a blow from nearly their whole loading; at the same time their mass is small—a high value should, therefore, be given to the factor of safety for these girders.

TABLE I.

Actual working loadings per foot run of span for a double girder, the movable loading being = one ton per foot run.		Strength required by Dr. Fairbairn's scale.		Strength required by Professor Rankine's method.			
				Factors = 3 and 6.		Factors = 3 and 4·5.	
Dead Weight W_1	Total Weight W	Breaking Weight per foot run.	General Factor or Breaking Weight ÷ W.	Breaking Weight per foot run.	General Factor or Breaking Weight ÷ W.	Breaking Weight per foot run.	General Factor or Breaking Weight ÷ W.
0·00	1·00	6·00	6·00	6·00	6·00	4·50	4·50
0·25	1·25	6·25	5·00	6·75	5·40	5.20	4·20
0·50	1·50	6·75	4·33	7·50	5·00	6·00	4·00
0·75	1·75	7.00	3·86	8·25	4·71	6·75	3·86
1·00	2·00	7·50	3·50	9·00	4·50	7·50	3·75
1·50	2·50	7.75	3·00	10·50	4·20	9·00	3·60
2·00	3·00	8·00	2·67	12·00	4·00	10·50	3·50
2·50	3·50	10·00	2·86	13·50	3·86	12.00	3·43
3·00	4·00	12·00	3·00	15·00	3·75	13·50	3·38
3.50	4·50	14·00	3·11	16·50	3·67	15·00	3·33
4·00	5·00	16·00	3·20	18·00	3·60	16·50	3·30
6·00	6·00	20·00	3·33	21·00	3·50	19·50	3·25
7·00	7·00	24·00	3·43	24·00	3·43	22·50	3·21
∞	∞	∞	4·00	∞	3·00	∞	3.00

We must object to the results given by Professor Rankine's method, for the reason that the general factor does not diminish at first with sufficient rapidity to represent the rapid diminution in the destructive effects of a train on changing from the shortest and lightest spans to somewhat longer and heavier ones; and for the very long and heavy spans the factor diminishes too markedly. This is the opinion we would be led to on viewing the subject independently of the stresses induced in the booms by the transverse lateral action of the wind, which it has hitherto been the custom to ignore; but when these stresses are allowed for, we apprehend that the general factor may, with sufficient accuracy for a general rule, be taken constant after reaching a certain value, such as 3·5. This assumes that after a certain point, any reduction that might be made in the factor on account of the smaller proportion of the movable compared with the fixed loading in longer spans, will be counteracted by the demand for additional strength on account of the detrimental action of the wind upon the booms. We may assume the width of structure as constant, the stress on the booms from the wind will therefore increase somewhat more rapidly than the square of the span; in long spans, furthermore, that increase in the effect of a blast which arises from the suddenness of its application may become augmented, and there is also an increased chance of the wind impulses corresponding with the oscillations of the structure. The destructive effects of the wind in extreme spans may possibly, therefore, become so great as to

demand a higher allowance than the above assumption affords.* As a general rule, however, we feel some confidence in recommending a uniform general factor of safety to be applied, without distinction, to fixed and movable loading† for wrought-iron railway-bridges of great spans, according to column 4 in Table II.

TABLE II.

Fixed loading per foot run, the movable loading being = 1 ton. W_1	General Factors of Safety according to		
	Dr. Fairbairn.	Professor Rankine (Special factors = 3 and 4½.)	Mr. Bow.
0·00	6·00	4·50	6·00
0·05	5·76	4·43	5·71
0.10	5·55	4·36	5·45
0·15	5·35	4·30	5·22
0·20	5·17	4·25	5·00
0·25	5·00	4·20	4·80
0·30	4·85	4·15	4·61
0·40	4·57	4·07	4·29
0·50	4·33	4·00	4·00
0·60	4·12	3·94	3·75
0·70	3·94	3·88	3·53
0·80	3·78	3·83	3.50
0·90	3·64	3·79	3·50
1·00	3·50	3·75	3·50
1·25	3·22	3·67	3·50
1·50	3·00	3·60	3·50
1·75	2·82	3·55	3·50
2·00	2·67	3·50	3·50
2·25	2·77	3·46	3·50
2·50	2·86	3·43	3·50
3·00	3·00	3·38	3·50
3·50	3·27	3·33	3·50
4·00	3·33	3·30	3·50
∞	4·00	3·00	3·50

The general factors for moderate spans are estimated by assuming 6 tons per foot run of span as the minimum value to be put upon the breaking weight. The decreasing series of values resulting from this is made to terminate at 3·5 as the lowest allowable factor, this term is reached when the fixed loading amounts to 0·714 ton per foot run, or 71·4 per cent. of the movable.

For really great spans, then, we have the uniform general factor of safety = $3\frac{1}{2}$, and for such spans we now proceed to investigate the weights of the girders.

The Weight of a Girder of Great Span.

Let s = the span for calculation, being, when correctly measured, the distance in feet between the centres of pressure on the supports.

* The relation of the values of w_1 (the fixed) and w_2 (the movable loading) has of course some influence upon the stresses in the braces, particularly upon the central ones, but for constructive reasons these braces are at any rate made with a great excess of strength, so that practically an increase in w_2 compared with w_1 would only necessitate the strengthening of the central diagonal ties to fit them to act more forcibly as struts under an irregular loading; the amount of extra material required would be so minute that we cannot regard it as affecting the above general rule.

† In cases such as the Conway-bridge, where we have a large flat surface exposed to the wind along with extreme narrowness of structure to resist it, additional strength must be provided.

Let W_1 = the gross weight of the length S of the complete structure due to one double girder; that is, the total dead weight borne by the girder or girders which have to carry a movable load = S tons railway bridges. $W_1 = W - W_2$.

Let W_2 = the movable load = S tons.

Let W = the whole load supported by a double girder = $W_1 + W_2$.

Let G = weight of the girder suited to carry the load W, but G does not include parts not directly required to fit it for supporting the load. $G = W_1 - F$.

Let F = all the fixed loading exclusive of the girder G; that is, F = the weight of cross-girders, planking, horizontal and transverse bracing, hand-railing, permanent way, &c. $F = W_1 - G$.

Prop. I. In any particular form and construction of girder of given span and depth and value of the factor of safety, we may, within practical limits, assume that G varies as W.

Prop. II. When W is constant but S variable, and the factor and the relation of the depth of girder to the span are constant, we may assume within limits which secure the struts against material weakening, that G varies as S. Therefore

Prop. III. In any special form and construction of girder in which S ÷ the depth D is constant, and in which the factor and the allowances of metal to the corresponding struts may be made the same, G varies as W S.

$$\text{Let therefore } G = WSk \quad . \quad . \quad . \quad (1)$$

$$k = G \div WS \quad . \quad . \quad . \quad (2)$$

k being a constant depending upon the value of the factor of safety directly, and inversely upon the economic merit of the structure; we may distinguish the value of k corresponding with any particular value of the factor by writing that value against it thus, $k_{3\cdot5}$; on this principle k_1 will indicate that the value is taken for the case of a breaking weight.

In formula (1) for W substitute its equivalent $W_2 + G + F$, and we have $G = Sk\,(W_2 + G + F)$, whence we obtain

$$G = \frac{Sk W_2 + F}{S1 - k} \quad . \quad . \quad . \quad (3)$$

Before we can make direct use of this important formula, we must describe the principles on which F is to be calculated or estimated for different structures; this, however, we must defer till our next paper.

We at once see from the formula that G, the weight of the girder, becomes infinite when $Sk = 1$, or $S = \frac{1}{k}$, and therefore points out the ultimate span for the particular construction corresponding with k. Then since k varies directly with the factor of safety, we see that the ultimate span for a breaking weight $\left(= \frac{1}{k_1}\right)$ will be $3\frac{1}{2}$ times larger than that which can be reached without overstepping the stresses we

have been led to consider judicious, (that is the ultimate span under proper stresses $= 1 + k^{3/5}$).

In our paper for next month we propose arriving at expressions for F, and thereafter deriving values of k from various structures, and will conclude with a table of the weights of girders of various spans, and constructed on different systems; showing the immense saving that may, and *ought* to be effected in large structures, by attention to the principles we have developed. In the meantime we append an article of some importance and of general application, which we shall require to make use of on resuming the subject of the Economic Construction of Girders of Great Spans.

(To be Continued.)

On the Value to be taken for the Depth of a Girder when applying the common Formula for its Strength.

From the Lond. Civ. Eng. and Arch. Journal, August, 1862.

If any girder in which the moments of the web may be neglected on account either of its thinness or openwork character, the stress produced by a uniformly distributed loading (=W) is in either of the booms equal to $\frac{WS}{8D}$, wherein D is the depth or distance apart of the booms treated as mere horizontal lines, and S the acting span. Now in applying this formula in practice, it becomes necessary to assign a value to D *less* than the extreme depth of the structure, since the booms are not simple lines, but must have some vertical dimension; and it is only the extreme layer which acts with the full force of C or eT,* and with full leverage of the extreme distance above or below the neutral axis.

Let M_1 be the sum of the moments of all the fibres of the bottom boom measured round the neutral axis; and M_2 = the sum of the moments of the various parts of the top boom. Now we require to find a point in the cross section of each boom so situated that were *all* the section of the boom acting there with the full force of C or eT, the moment (that is the full sectional area of the boom multiplied by the distance of the point from the neutral axis and by C or eT) will be equal to M_2 or M_1. Let A_1† be the sectional area of the bottom boom, A_2 that of the top boom, D_1 the distance of this point in the lower boom below the neutral axis, and D_2 the distance of the point in the upper boom above that axis.

Then $A_1 D_1 eT = M_1$, and $A_2 D_2 C = M_2$

$$D_1 = \frac{M_1}{A_1 eT} \text{ and } D_2 = \frac{M_2}{A_2 C} \quad . \quad . \quad . \quad (1)$$

$$D = D_1 + D_2.$$

The ordinary practice of assigning a value to D equal to the distance between the centres of the sections of the booms is so very far wrong, and liable to lead to such grave errors, that we feel it incum-

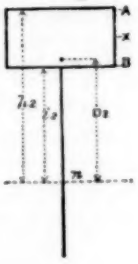
* The symbols here employed are the same as in the papers on "The Economic Construction of Girders."

† The areas and moments of the portions of the web of a plate girder could be readily introduced into the discussion, but such a mode of treatment would annul any advantage from employing the above simple formula for the strength.

bent upon us to enter into some detail, in order to show by examples the great difference between the correct results and those obtained by the usual modes of carrying out the calculation.

For this purpose we may restrict our attention to the parts and their moments on one side of the neutral axis; let it be that of the upper booms.

1st. When the upper boom consists of one or more rectangular cells. Let A be the area of the upper plates, B of the lower, and X of the vertical plates. Let h be the distance of the centre of A plates, and i = the distance of centre of B plates, from the neutral axis n in the diagram.



Then by formula (3), page 194 *ante* we have the moments.

$$C = (Ah + B\frac{i^2}{h} + X\tfrac{1}{3}\left(h + i + \frac{i^2}{h}\right)$$

and therefore to obtain D_2 we divide this by the area into C, *i.e.*, by $C(A + B + X)$, $\therefore$

$$D^2 = \frac{Ah + B\frac{i^2}{h} + X\tfrac{1}{3}\left(h + i + \frac{i_2}{h}\right)}{A + B + X} \quad . \quad . \quad . \quad . \quad (2)$$

Example.—Let the areas A, B, and X be taken all equal, and the formula becomes

$$D_2 = \frac{4h + i + 4\frac{i^2}{h}}{9}$$

by which we get, on assuming different ratios between h and i, the results given in Table I.

TABLE I.

Proportion of h : i.			Values of D_2.		Percentages of Error.
h	:	i.	Correct.	Usual.	
2	:	1	1·223	1·5	22·7
3	:	2	2·148	2·5	16·4
4	:	3	3·111	3·5	12.5
5	:	4	4·089	4·5	10·5
10	:	9	9·044	9·5	5.0

It will be perceived from the table that when i is not greatly less than h, the value of D_2 should be very little greater than i.

We have calculated by formula (2) the correct value of D for the Conway tubes, using the moments given in the foot-note at page 194 *ante**, and find it equal 22·067, the extreme depth outside being 25 ft. 5 in., and the inside depth 21 ft. 7½ in.; i, or depth between centres of plates B and C = $i_1 + i_2$ = 21·688.

Now this smallness of the value of D will account in a great measure for the extreme heaviness and weakness of the Conway (and Britannia) tubes, the proportion of span to depth being so great as

* Jour. Frank. Ins., vol. xliv. page 318.

$\frac{405}{22{\cdot}067} = 18{\cdot}35 : 1$, or, if we follow the less exact but usual course of taking the clear span, we have $\frac{S}{D} = 18{\cdot}13$.

The correct value of D for the large experimental tube in Experiment IV. is $= 4{\cdot}07$; the depth between the centres of the extreme top and bottom plates is $= 4{\cdot}53$, and between the centres of the bottom and lower top plates is $= 4{\cdot}015$. And the value of $\frac{S}{D}$ is $= \frac{75}{4{\cdot}07} = 18{\cdot}43$.

As many readers may feel surprised at the true value of the depth D coinciding so nearly with the value of i, we may, perhaps, make it clearer by considering the plates A and B of the diagram alone; and let us suppose these of equal areas and at distances from the neutral axis equal respectively to 10 and 9 feet. The true moments are—

Plate A, area=A, leverage=10, compression=C, ∴ moment=10AC
Plate B, area=A, leverage=9, compression=$\frac{9}{10}$C, ∴ moment=8·1AC

Sum of moments . . . . 18·1AC

Dividing by the whole area $= 2A$, multiplied by the full compression we have $C_2 = \frac{18{\cdot}1AC}{2AC} = 9{\cdot}05$ feet, or only six-tenths of an inch above the centre of the plate B.

To make this still more clear, let us compare the above arrangement of girder having the plates at 9 and 10 feet from the neutral axis, with a girder in which both plates are only 9 feet from the axis. Plate A in the latter acts with the same force C as in the former, but its leverage is reduced from 10 to 9 feet, so that its moment is reduced from 10AC to 9AC

Plate B, on the other hand, acts in the latter with the same leverage of 9 feet as in the former, but the force of its action is increased from $\frac{9}{10}$C to C, and therefore its moment is increased from 8·1AC to 9AC

Or the total moment . . . . = 18AC

being only $\frac{1}{18}$ part less or weaker than the girder so much greater in extreme depth.

From these facts some valuable hints may be taken as to the judicious designing of the booms of girders.

2d. We shall conclude for the present with another general example.

Let the top boom be supposed to be a solid rectangle, as in some timber bridges and roofs. For this our formula $D_2 = M_2 \div$ area C becomes simply

$$D_2 = \frac{1}{3}\left(h + i + \frac{i^2}{h}\right) \quad . \quad . \quad . \quad . \quad (3)$$

Assigning to h and i different relative values, we get the results in Table II.

TABLE II.

Ratio of h to i. h : i	Values of D_p. Correct.	Usual.	Percentages of Error when D is taken. As Usual. In Excess.	$= i$. On safe side.
2 : 1	1·167	1.5	28·6	14·3
3 : 2	2·111	2·5	18.4	5·3
4 : 3	3·083	3·5	13·5	2·7
5 : 4	4·067	4·5	10·7	1·64
6 : 5	5·056	5·5	8·8	1·3
7 : 6	6·048	6·5	7·5	0·8
8 : 7	7·042	7·5	6·5	0·65
9 : 8	8·037	8·5	5·7	0·50
10 : 9	9·033	9·5	5·2	0·4

Edinburgh. R. H. B.

Passage, on the Level, of a Torrent across the Canal du Midi.

From the Lond. Civ. Eng. and Arch. Journal, Aug., 1862.

Among the very interesting and instructive collection of models and drawings of French engineering works now in the International Exhibition, may be seen a model $\frac{1}{25}$th full size and two drawings, representing a work certainly unique in its character,—no other than the passage, on the level, of a torrent across a canal. The torrent in question is the Libron, which crosses the last level but one of the Canal du Midi (called the level de l'Ecluse Ronde), at a distance of 1300 metres from the Mediterranean. Often dry, and commonly containing but a scanty supply of water, the Libron suddenly assumes in wet weather the character of a violent torrent, bringing with it masses of sand and gravel, detached from the friable mountains and rocks among which it takes its rise.

At the point where it crosses the canal, the bottom of the bed of this torrent is even with the higher level of the water, which only exceeds the mean height of the sea by 90 centimetres, or about 3 feet. This circumstance rendered it impossible to construct such a work as would in ordinary cases be employed to keep an artificial watercourse clear of the natural streams with which it meets.

The inadequacy of the fall made it impossible to take the Libron under the canal by a syphon aqueduct, which would have been liable to get constantly choked with sand. And the carrying the canal by an aqueduct above the highest floods of the Libron, was also in a sense impracticable, since it would have involved raising the canal many metres above the level of the plain, for a distance of more than 20 kilometres (12 or 13 miles).

During the first years of the execution of the canal, the Libron had no determinate bed. After rains its waters spread over the plain and discharged themselves at many points into the level de l'Ecluse Ronde, filling it with sand and gravel to such an extent as to render dredging necessary to restore the navigation interrupted by these deposits.

The first step taken was to confine the waters to a single bed, and

carry the stream across the canal through a species of lock or basin having transverse and wing walls, the course of the canal through the lock being commonly open, but closed during the rains by strong dams; which were fixed by means of grooves in the masonry, and removed after the turbid waters had spent themselves. This arrangement confined the silting up of the bed of the canal to one spot; but the barges were stopped not only during the continuance of the floods, but also during the placing and removal of the dams, and the re-excavation of the basin.

Subsequently these interruptions of the navigation were shortened by placing in the basin a pontoon having its deck level with the bed of the stream, and having at its sides wooden bulwarks of sufficient height to convert it into a species of aqueduct deep enough to carry the flood waters. In ordinary weather this pontoon was moored on one side, out of the way. In seasons of flood it was placed across the basin, so as to form a distinct channel for the torrent, and while in this position it of course stopped the passage of the boats.

At length, after the stoppages of the year 1853 (which extended over no less than a hundred and five days), it was resolved, instead of replacing the pontoon, which had given way under the weight of gravel and sand deposited on it, to try to devise an expedient for keeping the navigation uninterrupted. This end was attained by means of the present work, of which the following is a description:

At the meeting of the Libron and canal two new beds or branches, symmetrically placed, were dug for the stream, starting at 50 metres above the canal, and reuniting at the same distance below it. These two branches, each of which is of equal section with the old bed, are separated by a basin exactly similar to a lock, and affording room for one boat.

In these two branches are placed, on each side of the canal, and in a direction parallel with it, an equal number of archways dividing each arm into bays, which can be closed against the stream by floodgates working in timber framing. By means of these floodgates the torrent can be stopped, and caused to flow through whichever channel is desired.

To keep the turbid waters from mingling with the waters of the canal, movable aqueducts or troughs of timber are provided, two in each bay, of the same width as the bays, and of a length equal to half the width of the canal. These troughs are suspended from trucks, which run on rails carried on vaults of masonry, which are built across the canal.

During floods the torrent passes alternately through each of the two branches, as they are opened and closed by the sluices. In the branch where the floodgates are open, the troughs are brought together, so as to cover the entire surface of the basin corresponding to each bay. While in this position they stop the passage of the boats. On the other hand, in the branch of which the floodgates are closed, the troughs are withdrawn into the recesses contained between the abutments of the vaults thrown over the canal and the arches, leaving

an open passage for the boats. These recesses are made deeper than the bed of the torrent in order to take the troughs, and are covered with movable flooring, to prevent the silting up which would otherwise impede the movement of the troughs.

It will readily be understood that from whichever side a boat approaches (during floods) the torrent is turned through the further channel, until the boat passes into the lock in the middle, where it is made fast. The troughs of the branch which the boat has to pass through are then run together, the flooring lowered, the sluices drawn up, and the torrent flows for some moments through both branches at once. As soon as the stream has set well on the side by which the boat entered, it is stopped in the other branch by closing first the up-stream and then the down-stream sluice. What water remains is run off into the canal by a valve provided in the partition of the troughs. The flooring in the recesses is then raised again, and the troughs are run back, leaving the passage open for the boat to continue its journey.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Momentum. By JOHN A. GRIER.

There is no term used by writers on the mechanical sciences that seems more important to define than this, and none which appears to have a more indefinite meaning.

By the term *momentum*, I mean "the force accumulated in a moving body." Two terms, *momemtum* and *vis viva*, are generally used to express this accumulation of force. Sometimes it is defined as a quantity varying as the weight multiplied by the velocity,—then again as half the weight multiplied by the square of the velocity, and, again, as the weight multiplied by the square of the velocity. The latter is I believe the most generally accepted theory among the leading constructors of our railroads and bridges,—our armaments,—our engines and vessels.

If this large class of most eminent men made no mistakes, or taught no errors, I would not dare to pen this article. However, I will advocate no really new dogma, as Olmstead, Playfair, and Newton are among its supporters, yet I do not wish to hold them responsible for any of my own deductions.

I will endeavor to prove that the momentum or quantity of force accumulated in a moving body, varies *as the weight multiplied by the velocity:* and that the resistance a moving body will overcome, varies as the momentum, and that the velocity will vary as the quantity of force expended. The laws of gravity are so well understood, and for our present purpose are most convenient. The force of gravity is a uniform force, and hence in equal times, will exert equal quantities of force whenever it is left free to act upon a moving body. Omitting to take any account of atmospheric resistance, and neglecting what are in the present consideration unimportant fractions, we

find that a body near the surface of the earth left free to the action of gravity, or free to fall, will move through sixteen feet of space during the first second, and acquire a final velocity of thirty-two feet per second, and during two seconds will move through sixty-four feet of space, and acquire a final velocity of sixty-four feet per second.

By inquiring into the cause of this increased space moved through and increased velocity acquired during the last of the two seconds, we see that it is most easily explained. The uniform force of gravity is exerted on the moving body equally during each of the two seconds, yet the results at first sight do not appear the same. As we have seen during the first second, sixteen feet is moved through and a final velocity of thirty-two feet per second is acquired, while during the last second, forty-eight feet is moved through, and a final velocity of sixty-four feet per second is acquired. However, we wish to prove that the expenditure of force is the same during each second, and also, that although a body in this case moves over four times as much space in two seconds, as it does during the first of these two seconds, still the *space moved through, is no true criterion of the force expended, or of the resistance overcome.*

Gravity exerting its full force on this body for one second moves it through sixteen feet, and gives it a final velocity of thirty-two feet per second; this final velocity will carry the body through the next thirty-two feet during the last of the two seconds without any extra expenditure of force by gravity, but the body receiving the same quota of force during the last second that it did during the first, hence the body is moved through forty-eight feet during the last second, and acquires a final velocity of sixty-four feet per second.

Thus it appears that although the space moved through during two seconds, is four times as great as that moved through during the first of these two seconds, when a body is left free to the influence of the force of gravity, yet the quota of force expended during two seconds is *not* four times as great as the quota of force expended during the first of these two seconds.

Hence "*the actual work done*," "*the resistance overcome*," "*the mechanical effect*," "*the force accumulated or stored up in the moving body*," "*the momentum*," "*the vis viva*," or by whatever term we may choose to call *this result* of the action, of the uniform force of gravity on the moving body, is only twice as great for two seconds as it is for the first of these two seconds.

At any point of descent a body would return to the height from which it fell, if all the force expended on it down to that point were left free to act upon it in an upward direction. At the end of two seconds as the velocity of the falling body is sixty-four feet per second, then let it commence to ascend at that point; during the first second of its ascent it will move through forty-eight feet, and have a final velocity of thirty-two feet per second, and during the next second it will go through sixteen feet, and have a final velocity reduced to zero.

Hence again it is true that the work done or resistance overcome in the first of these two ascending seconds, is equal to that done during the last of these two ascending seconds. Because the only resistance

overcome is the uniform force of gravity which resists the ascending body with a certain definite quota of force during each second of the time it is left free to act. The *time* during which any uniform force acts freely on a body, and *not the space* through which it moves the body, is the only unvarying and true criterion of the work done, or of the force stored up, or accumulated in the moving body. *If* the force expended by gravity during two seconds is four times as great as the force expended during the first of these two seconds, then the accumulated force should be four times as great at the end of the two seconds, as it would be at the end of the first of these two.

We have shown that this quadruple force has not been *expended* and hence it is not *accumulated*. As the velocity varies as the time, then the force accumulated varies as the velocity, or as the weight into the velocity. *Thus a double expenditure of force gives a double velocity, and a double velocity gives a double momentum. Hence the momentum will vary as the weight multiplied by the velocity.*

If we measure the force accumulated in a moving body by the length of time it is expending this accumulated force in overcoming a resistance uniform *as to the time*, then it is evident that it varies as the weight multiplied into the velocity.

But if we measure the force accumulated by the force expended in overcoming a resistance uniform as to the time, but *not uniform as to the space*, by the space through which a body is moved while the accumulated force is being expended, then it will vary as the weight multiplied by the velocity squared.

The former of these measures is usually called *momentum*, while the latter is called *vis viva*, and in reality there is no more difference between their meaning, than if we at one time should say a yard was three feet, and at another time thirty-six inches in length: momentum being the term used when the element *time* is taken into consideration, *vis viva* when *space* is taken into consideration. But when the resistance is not *uniform as to the space*, space cannot be a true criterion of the force expended; hence the term *vis viva* understood in this way is very indefinite. From this simple cause alone arises the great confusion of ideas on this subject.

Some persons may consider this a dispute about words only, but when we see authors of eminent practical abilities, such as Bourne the great English engineer, boldly teach that the momentum of a moving body varies as the weight multiplied by the *square of the velocity*, and that it is necessary to double the expenditure of force to obtain a double velocity; it is most evident that the dispute is not only about words.

It is on this hypothesis that he advances and endeavors to prove that the force necessary to be expended in overcoming the front resistance of a vertical plane moving through a fluid in a vertical direction, will vary as the *cube of the velocity*.

This theory is so generally believed, I almost fear that the prejudice in favor of it alone, may prevent many from ever giving this article a patient thought.

In the study of the abstruse subject of fluid resistance, my attention was first attracted to the confusion of theories taught on this vital principle of momentum. It is fit, then, that I should mention it in connexion with the present subject. The bearing that this question has on projectiles and iron-clads is also eminently practical.

Does the resistance a shot would overcome vary as the weight into the final velocity, or as the weight into the square of the final velocity, other things being equal? Our deductions would teach us to believe in the former of these measures, in opposition to the theory usually taught by practical men on such matters.

Both in steamship propulsion and in gunnery there are so many varying elements brought to bear in developing the force as well as in expending it, that it is impossible to determine the exact quota of force expended in overcoming each species of resistance.

I will conclude this article with an account of some crude experiments I have made, having a relation to this subject.

I dropped a small iron rod from the height of four feet so that it acquired a velocity of sixteen feet per second, and then dropped the same rod through sixteen feet, so that it acquired a final velocity of thirty-two feet per second, and on measuring their respective penetration in sand found that *the penetration varied as the velocity.*

Then I dropped a rod of the same sectional area, but of half the length of the first one, from the height of sixteen feet so that it acquired a final velocity of thirty-two feet per second. Its penetration in the sand was the same as the larger one dropping with a final velocity of sixteen feet per second. These results were not mathematically as I have stated, but the average penetration in these crudely conducted experiments is all I profess to give. To me they appeared as very conclusive evidence that the penetration of shot, other things being equal, will vary as the weight into the velocity, or as their momenta.

I also arranged a delicate steel spring with a trigger attached, so that I could let it re-act suddenly when compressed.

A weight bent it one degree, a double weight two of these degrees of tension, a triple weight three degrees. On allowing the spring to re-act at one degree of tension, it would throw a shot lying on it a certain height, but when let go at two degrees it would throw the shot to four times the former height, and at three degrees to nine times the height. Thus again seeming to prove that a double force would throw the body to a quadrupled height, and a triple force to nine times the height. The time the force of gravity would act on the respective ascending shots would vary as one, two, and three for their respective efforts.

These experiments were but rudely executed, but in all their simplicity they seemed to be very conclusive.

I hope a patient reading of this brief article *may do something* towards reconciling any discrepancy that may exist on this most important and interesting subject.

The Principles of Spectrum Analysis. By THOMAS ROWNEY.

From the London Intellectual Observer, June, 1862.

Sixty years or more ago Dr. Wollaston detected in the spectrum obtained from solar light a series of dark bands crossing it throughout its entire length. These lines may be easily seen through a prismatic telescope, of which Mr. Crookes has contrived a simple form. The discoverer does not appear to have thought much of the fact, and seems to have discontinued his experiments, as we have no further account of his researches in that direction. It was not until Fraunhofer of Munich announced his independent discovery of the same lines, and showed that they were constant both in number and position, and mapped them out to the extent of more than 600, with the most sedulous care, that they came to be regarded as features worth notice. He showed that these lines, which now bear his name, might be found in all spectra, by viewing them through a telescope, whether the source of light were the sun, moon, fixed stars, or planets. He also found them in the electric spark, and in flames colored by the combustion of metals. These two philosophers might justly lay claim to the honor of having laid the foundation of what is now termed spectrum chemistry. In the words of Dr. Miller:

"The inquiry thus launched by Fraunhofer has been followed in four principal branches of research, which may be described as relating to,—

"1. *Cosmical lines*, or the black lines produced in the light of the sun, the planetary bodies, and the fixed stars.

"2. *Black lines produced by absorption*, a class of phenomena discovered by Sir D. Brewster, in his observations upon the red vapors of nitrous acid.

"3. *Bright lines produced by the electric spark*, when taken between different conductors.

"4. *Bright lines produced by colored flames*, or by the introduction of different substances into flames.

"The following chronological table contains the names of those who have made the principal steps in these different subjects:—

"Newton	1701.
Wollaston	1802.
Fraunhofer	1815.

COSMICAL.	ABSORPTION BANDS.
Brewster, 1832.	Brewster, 1832.
E. Becquerel, 1842.	W. H. Miller and Daniel, 1833.
Draper, 1842.	W. A. Miller, 1845.
Stokes, 1852.	
Brewster and Gladstone, 1860.	

Electric Light.	Colored Flames.
Wheatstone, 1835.	Brewster, 1822.
Foucault, 1849.	Herschel, 1822.
Masson, 1851–55.	Fox Talbot, 1826, 1833, 1834.
Angstrom, 1853.	W. A. Miller, 1845.
Alter, 1854–55.	Swan, 1857.
Secchi, 1855.	
Plückner, 1858–59.	
V. Willigen, 1859.	
Kirchhoff . . 1859.	
Kirchhoff and Bunsen . 1860."	

In order to a right understanding of the results which have been reached by the recent labors of Kirchhoff and Bunsen, it is necessary to be acquainted with the nature of the dark lines, which are so many touchstones or tests by which they have worked them out. Let us suppose a prism of blue glass to be used for effecting the decomposition of a ray of solar light. We have an elongated image, not, however, containing seven colors, as when a white prism is used. The yellow, blue, and green are all absorbed, and we have only the two extreme colors, violet and red, the latter also diminished in breadth. A comparison with the normal spectrum will make the difference at once clear. In passing through our atmosphere, or the atmosphere of the sun, similar changes may take place, and thus materially assist in producing these dark lines. Moreover, there are a class of rays in the solar spectrum which our eyes cannot see, and of which we can only judge by their effects. Of such are the chemical rays which manifest their action in the beautiful results of the photographic art. We may instance also another set found beyond the violet rays, whose presence has been demonstrated by Professor Stokes, by transmitting them through a solution of sulphate of quinine. They have a light bluish-lavender color. Thus, it will seem that certain rays have such a refrangibility that our eyes cannot take cognizance of them; and so also certain rays exist in solar light which are incapable of transmission through certain media. Applying this to the solar spectrum, we have a clue to the production of the dark lines, by supposing, with Kirchhoff and Bunsen, that the sun has the property of inducing or giving out rays of a certain refrangibility, but yet cannot produce others capable of filling the interspaces. Another interpretation has been given, by supposing an interference in the undulations of certain rays, which produce darkness; but this theory will not meet the circumstances of the case, and we can show by experiment that by making an artificial atmosphere the same or parallel results can be produced.

The natural variations in the composition of the atmosphere produce similar effects, and Brewster was the first to notice bands in the red and green spaces, whose appearance was not constant. These appearances are usually observed when the sun is not far from our horizon; and Dr. Miller mentions an instance in which he saw a group of lines

during a thunder shower. They came suddenly, and faded as the rain passed away.

The readiness with which the spectrum responds to changes in the atmosphere, or in the nature of the source of light, is shown in the following experiment of Kirchhoff and Bunsen :—

They threw up into the air of the apartment a small quantity of chloride of sodium in very fine powder. Motion was imparted to the atmosphere, to insure an equable diffusion of the salt. The spectrum in an instant demonstrated its presence, by showing a golden-yellow band in the yellow space. This effect is uniform whenever sodium is present in a state of incandescence, and is therefore called the sodium spectrum. This result might have been expected, knowing that sodium in any form always tinges flame an intense yellow ; but when we come to the combustion of other metals, the bands produced by them are such as could never have been anticipated. When silver is burnt we have other colored bands brought out equally characteristic, and so with every other metallic substance. To show the relation between these colored bands and the dark lines, we will suppose the light of a pure white flame to be passed through a yellow sodium flame, and then through the prism. Now, mark the change. The spectrum is no longer continuous, and having its bright yellow band in the yellow space ; but where it flashed out so conspicuously is now to be seen a dark line, known as " D." The rationale is obvious. The yellow atmosphere has interfered with the yellow of our normal spectrum, and by that interference darkness has resulted.

Keeping these results in view, we have a key to the whole subject of spectrum chemistry. It can be shown that each metal in a state of vapor has the power to arrest particular rays with a constancy that can be relied on. The arrangement best suited for these experiments is either Dubosq's electric lamp, or the Drummond light, but many of the spectra may be conveniently studied by using Crookes's spectroscope, as made by Spencer Browning and Co., and now too well known to need detailed description. This instrument is well adapted for ordinary purposes, but to appreciate the full beauty and delicacy of the various spectra, we should need an apparatus as perfect as that constructed for Kirchhoff by Steinheil of Munich.

When artificial light is employed—as that of gas or lamp—the dark lines may be brought out by interposing a glass trough or bottle containing nitrous acid gas between the light and the instrument. This gas may be obtained by the action of a small quantity of nitric acid on a piece of copper ; and, as we have before mentioned, it acts as an absorptive medium. If a piece of sulphur be introduced into the flame of a spirit-lamp, a good view of its dark bands may be obtained. If the subject for examination be an alkaline metal, the spirit-lamp may be used, or better still, a flame of hydrogen mixed with air and burnt on the top of a tube covered with wire gauze. We thus obtain a flame of high temperature with little light, except what is derived from the substance employed. The metal in a state of chloride is the most convenient form—it being more easily volatilized. It may be introduced

into the cotton wick; or if the gas-burner be used, then a loop of platina wire sliding on an upright support is the easiest to manage. The copper spectrum may be readily obtained by dipping a coil of fine wire into pure hydrochloric acid, and immediately inserting it into the gas-flame. When iron, silver, &c., are operated upon, wires of these metals should form the electrodes of a powerful voltaic battery, and be brought by its agency to an incandescent state, when a portion of their substance is volatilized, and exhibits its characteristic action through the prism.

Kirchhoff and Bunsen, while pursuing their researches on the composition of some mineral water, obtained from the combustion of the solid matter a series of bands in two spectra, which did not correspond with those produced by any of the known metals. This led them to infer the presence of some new elements which the eye of man had never yet seen. After evaporating several tons of the fluid, their labors were rewarded by obtaining two new metals, which they named Cœsium (greyish blue)—that being the color of the bands—and Rubidium (dark red). No sooner had they done this than they were off into the depths of speculation, conceiving that they had in their power a means of analysis capable of much higher application.

These ingenious and indefatigable workers found that the bright lines in the metallic spectra corresponded closely with the dark lines of the solar spectrum. Why was this? and how could it be explained? They found, by experiments before cited, that each color was opaque to rays of its own color.

To illustrate the point more clearly, we may suppose two pendulums of equal length to be placed side by side. If the one be made to vibrate, it will, after a time, cause its companion to do the same in consequence of its equal length or isochronous condition; and so it is supposed that the rays of one color will be taken up by another whose vibrations are of equal length, and so be arrested in their voyage. Now look at the application of this result. If, in the rays of light from an artifical source, this principle be correct, it may also be correct with the rays of solar light. Hence they have inferred that the dark bands of the solar spectra are produced by their passage through an atmosphere containing certain metals in a state of high combustion or vapor.

Upon these grounds they have concluded that in the outermost solar envelope exist all those metals in a state of vapor, whose color-bands coincide with dark lines of the solar spectrum, as sodium, potassium, iron, and nickel; and that it is by the more powerful light of the photosphere shining through this only feebly-luminous layer that the dark bands of Fraunhofer are produced by the process before described. They have also inferred the source from which these metals are derived to be the mass of the sun. A bold assertion, perhaps a correct one; but we are certainly not at present justified in accepting it as if it were proved; and we may advantageously reflect upon the words of Dr. Miller:—

"Fascinating as this theory is, it must be remembered that it is yet

upon its trial, and that it does not explain the facts at present known respecting the vapors of hydrogen, mercury, chlorine, bromine, iodine, and nitrogen. M. Morren even questions the accuracy of some of Kirchhoff's observations. Thus, he states that in a measurement which he made of the red band of potassium, conjointly with Plücker, they found that it did not correspond with the solar line A, but that it is considerably more refrangible."

There are many other important facts which will have to be considered before we can arrive at a complete theory of the spectral phenomenon. For example, chloride of lithium produces a single crimson line in the flame of a Bunsen burner; the greater heat of a hydrogen flame enables it to emit an orange ray, and the voltaic arc adds a brilliant stripe of blue. In like manner, iron and other metals furnish spectra which advance in complication as the temperature of their vapor is increased.

Professor Roscoe says that "the general rule is that *luminous solids* give off a different *quality of light* when they are differently heated, and luminous gases give off the same kind of light at all temperatures." The spectra of gases are quite as interesting as those of the metals; hydrogen, for example, giving a red and a blue band, and nitrogen beautiful violet stripes.

On the use of Mica for Preserving Gilding, &c.

From the Mechanics Magazine, August, 1862.

In Paris, mica has lately been applied for preserving, silvering, and gilding decorations in churches and public buildings. The mica is first cut to the desired thickness with a knife, and is then coated with a thin layer of isinglass diluted in water, and the gold or other substance is applied, after which it is allowed to dry. A pattern of copper, with a design cut out on it, is then placed on the reverse side of the mica and the superfluous parts are removed. The colors are then applied in one or several coats, and the whole afterwards coated with a solution of isinglass and diluted alcohol, by which the mica is rendered pliable. When this is effected, the mica is applied to the object, which is coated with glue or other adhesive material, and allowed to become comparatively dry, after which the surface is made smooth by rubbing it gently with an agate burnishing tool. The value of mica depends on the size of the sheets and their transparency, the clear ruby-tinged being the finest, and the cloudy grey the least valuable.

Mountain Barometer.

From the Intellectual Observer, July, 1862.

Under this title Messrs. Horne and Thornthwaite have produced a very excellent aneroid, especially adapted to facilitate the measurement of heights. Being only 2½ inches in diameter, it is very portable, while from the excellent workmanship, no practical loss of efficiency is the consequence of its reduced size. The face is graduated in two

circles, the outer one giving the barometrical pressure in inches and tenths of an inch. Below this is the second circle, upon which the peculiar convenience of the instrument depends. This is graduated in spaces corresponding with hundreds and thousands of feet, so that a mere inspection is sufficient, without any calculation, for the measurement of ordinary heights. Thus, if the hand points to 1000, and on being carried to an elevation indicates 1100, it is evident that the last station is 100 feet higher than the first. Where the elevation to be measured is considerable, there will be a difference of temperature between the upper and lower levels, which must be allowed for to obtain a correct result; and the makers of this instrument supply a convenient and easily worked table, calculated in degrees of Fahrenheit according to the formula of La Place. To test the accuracy of the instrument, we have made repeated trials with heights of 20 or 30 feet and upwards, always obtaining closely approximate results. We have also compared its indications with a mercurial barometer, and observed its prompt indications of slight changes in the density of the air. We have likewise carried it loose in our pockets during long walks, and on two railway journeys, to see if a good shaking would do it any harm. The result of these experiments has been very satisfactory, and we can, therefore, recommend it to the tourist as a pleasant companion, serving the double purpose of a good barometer and measurer of heights.

Proceedings of the Association for the prevention of Steam Boiler Explosions.

From the Journal of the Society of Arts, No. 500.

At the ordinary monthly meeting of the Executive Committee of the Association, held July 30th, Mr. L. E. Fletcher, chief engineer, presented his monthly report, of which the following is an abstract:—

During the last month there have been examined 323 engines and 563 boilers. Of the latter, two have been examined specially, one internally, 95 thoroughly, and 465 externally, in which the following defects have been found:—Fracture, 16 (2 dangerous); corrosion, 46 (8 dangerous); safety-valves out of order, 11 (1 dangerous); water gauges ditto, 19 (4 dangerous); pressure gauges ditto, 14; feed apparatus ditto, 11; blow-off cocks ditto, 28 (1 dangerous); fusible plugs ditto, 6; furnaces out of shape, 10 (3 dangerous); blistered plates, 7; total, 168 (19 dangerous). Boilers without glass water gauges, 12; without pressure gauges, 2; without blow-off cocks 50; without back pressure valves, 98.

Three explosions occurring during the past month, to boilers not under the inspection of this Association, have come to my knowledge. One of these took place in Manchester, the other in the neighborhood of Newcastle, and the third in London, while all three were attended with fatal consequences. The plates of the first are reported as having been found on subsequent investigation so reduced by corrosion, as not to have exceeded the thickness of a sheet of paper; while it is

worthy of remark, with regard to the second, that its explosion had seriously damaged another boiler alongside of it, which, however, fortunately happened at the time to be out of work, or, from the injuries it received, it must have exploded in turn. This is frequently found to be the case, and the fact is of interest, as affording an indication of the variety of forces developed by explosion, which, as has been previously pointed out, evidently cannot be summed up merely in that of disruption and the re-action consequent on unbalanced pressure.

In addition to the above, however, it becomes my duty to report the occurrence of an explosion to one of the boilers belonging to a member of this Association, and which, it is to be regretted, was attended with loss of life to the fireman.

This is the third fatal explosion which has happened to any of the boilers under the inspection of this Association since its establishment, nearly eight years ago, to which should be added three cases of collapse of furnace flues, not attended with any serious consequences, and which arose in two instances, if not in all three, from shortness of water. During this period, 656 dangerous defects have been pointed out in the boilers under inspection, from which serious injury might have arisen in each case; while, upon limited inquiry only, it has been found that no less than 202 fatal explosions have occurred in that time to boilers not under the inspection of this Association, which have been attended with the loss of 438 lives, in addition to serious injury to 476 persons, and considerable damage to property.

The explosion last referred to occurred to one of a pair of ordinary cylindrical double-flued boilers, working side by side and connected together. Both boilers were upon mid-feathers, and were of precisely similar construction and dimensions, the length of each being 34 feet, the diameter of the shells 7 feet, of the flues 2 feet 7½ inches, and the thickness of plates ⅜ths of an inch throughout, with the exception of the flat ends, which were $\frac{9}{16}$ths of an inch. The fittings consisted in each case of a glass water-gauge; a back pressure and feed stop-valve combined; a blow-out valve, of mushroom construction, opening against the pressure in the boiler; and a lever safety-valve, loaded with a single weight to a pressure of 35 lbs. per square inch; in addition to a steam pressure gauge common to both boilers as long as both junction-valves were open, but not otherwise.

The explosion was occasioned by a rent in the shell, which took place directly through the line of rivets, at one of the longitudinal seams in the second ring of plates from the front of the boiler, the seam being on the right-hand side, three feet from the centre or "keel" line at the bottom. The construction of the seam was such that the edge of the outer plate was uppermost.

The cause of the rent was thinning of the plates at this seam, by external corrosion, through which it had become reduced to about $\frac{1}{16}$th of an inch in thickness. The corrosion extended throughout the length of the seam, which was 2 ft. 6 ins., and affected the plates on both sides of the lap to a width of from four to six inches. The rent did not extend longitudinally beyond the limit of this ring of plates, but ran along

the transverse seams of rivets on each side of it, almost severing a complete belt from the boiler. The re-action from this opening raised the boiler momentarily almost on end, as was attested by the character of the fracture of the connexions, the indentations in the bottom plates, and the fact that a pipe, previously overhead, had become buried beneath it, while the twin boiler along side was blown bodily in a lateral direction. Had the longitudinal seams of the rivets, instead of breaking joint, been in line, which is too frequently the case, the rent would certainly have run from one end of the boiler to the other, and the destruction of property, and very probably that of life also, have been most serious.

This defect was one that could scarcely have escaped detection on a careful examination of the condition of the plates in the external flues. Still, it should be borne in mind that the plates of boilers set on midfeathers are neither as accessible nor as visible as they are in those set on two side walls with a split flue. The side flues in the latter case admit of coming face to face with the plates and seams in a manner which cannot be done in the former, in which many of them can only be seen obliquely at a very great disadvantage, while those at the upper part of the flue, in what may be termed the tip of the wing, are frequently out of reach altogether.

All the members must be aware that, for the express purpose of detecting such defects as the above, the association affords, in addition to the external inspections, the opportunity of having every boiler "internally and thoroughly" examined at least once a year. The importance of these "thorough" examinations has been repeatedly called attention to, and every opportunity taken to promote their being made, and, in order to suit the convenience of members as to time, the ordinary routine of visits is entirely set aside at holiday times, such as Whitweek, Christmas, Easter, and race weeks, so that the inspectors may exclusively devote themselves to this special service.

It is much to be regretted that the Association was not afforded the opportunity of making a "thorough" examination of this boiler, either in the year 1860 or 1861, and when, in consequence of attention being specially called to this omission, our inspector, at the request of the owners, visited the works last Easter, the boiler was found unprepared, the flues being imperfectly swept, and the plates coated with soot, although the visit had been expressly appointed, in order to effect a "thorough" examination. Under these circumstances, no satisfactory examination could be made, which was distinctly stated to the engineer at the time, and subsequently officially reported to the owners. So clearly was this understood, that the next time the boiler was stopped the manager of the works went up the flue himself in order to complete the examination, which the want of preparation had previously prevented our inspector from doing.

It is hoped that our members will see from this the absolute necessity of having their boilers prepared for examination. They certainly cannot fail to remember how constantly this has been pressed upon their attention. A note referring to it appears at the foot of every

notice forwarded to them of the inspector's proposed visit, and another in the report on his examination, while reference was made to the subject in the chief engineer's monthly report for June, sent to each member; and, in addition, attention is frequently called by special letter, as it was in the present instance. Had it not been for its practical importance, so much had not been said upon so uninteresting a subject, and apology has sometimes been felt necessary for its frequent introduction. Still, dry or not dry, it is often a question of explosion or no explosion.

Yet another word before dismissing this subject. To expect an inspector to wait while the flues are being swept, as is too frequently the case, is really unreasonable, and compliance could only result in the accommodation of one member at the expense of another, while it would induce such disorder and breach of appointments as would only lead to a general dead-lock, especially in such a thronged time as every holiday week is, when the inspectors have one continuous string of engagements for these "thorough" examinations, from its beginning to its close, many of them being fixed for more than a month previously.

It may be added that the engineer who lost his life had been in the habit of going up the flues every month after they had been swept, and yet did not detect the corroded seam. This either shows that the corroded plate was concealed from view in some way in which it was impossible to account for after the explosion, or else is a witness to the necessity of competent inspection. That sweeps cannot be trusted to do engineering work is also clear.

For the Journal of the Franklin Institute.

Notes of Shipbuilding and the Construction of Machinery in New York and Vicinity.

Notwithstanding the dark clouds of civil war which hang over our country at the present period, there is great activity manifested in the various ship-yards and machine-shops of New York and vicinity. It is true that the prominent feature of the work in progress comprises the construction of vessels of war for our Government, demanded by the exigencies of the times; but they do not monopolize the whole of it, as during the past year many magnificent steamships of large tonnage have been constructed for private individuals, and others are now on the stocks, or undergoing the process of completion. Many of these vessels, however, have been sold, or chartered for an indefinite period, to the Government, and now are being used as gunboats or transports.

It is an indisputable fact that the shipping interests of the Northern States have been for the past fifty years steadily on the increase, and but temporarily interfered with by the several financial crises we have passed through in that time. Although we have never boasted of the immensity of our tonnage, we have advanced with that steady and marked progress which has attracted towards us the attention of European countries, and they have expressed their astonishment at our

enterprise and energy in Naval Architecture, and the excellency of our machinery.

Science and art have extended their aid in no other department of handiwork more particularly than in this, and the appreciation of the fact that our models of vessels, and the skill and ingenuity manifested in their construction, are universally regarded as of a superior order, is practically shown by numerous foreign nations, who fly their ensigns over the decks of many formidable men-of-war composing their fleets, whose construction is due to American skill and American ingenuity. And more than this, many of their citizens are owners of vessels of fine models, well constructed, sent forth from our yards, and now plying their seas.

If more evidence of this character is required to prove my assertion, I think the fact that special agents, recently sent to this country by foreign powers to superintend the erection of vessels intended for them, now being constructed at the yard of one of our most successful shipbuilders, will certainly be sufficient.

During the past few days I have visited the several ship-yards and machine-shops to be found within New York and vicinity, and as a result of my observations and inquiries, I present herewith annexed a review of the operations for the past six or eight months, together with those now in progress. It will give an impression of the state of the business, and as a matter of future reference alone they are of much interest:

The Steamer Continental.—Hull built by Samuel Sneden & Co., Greenpoint, L. I. Machinery constructed by Morgan Iron Works, New York. Owners, New York and New Haven Steamboat Co. Route of service, New York to New Haven.

Hull.—Length on deck, 282 ft. 6 ins. Breadth of Beam, 35 ft. 8 ins. Depth of hold, 11 ft. 5 ins. Draft of water, 6 ft. 6 ins. Frames—molded, 6 ins.—sided, 12 ins.—apart at centres, 24 ins. Tonnage, 1130 tons.

Engines.—Vertical beam. Diameter of cylinder, 70 inches. Length of stroke of piston, 11 ft.

Boilers.—Two—tubular—located on guards, and have one blower to each.

Paddle Wheels.—Diameter over boards, 34 ft. No. of blades, 32. Material, wood.

Remarks.—This steamer is built of white oak, &c., and around her frames diagonal and double laid iron straps are running.

The Steamers City of Boston and City of New York.—Hulls built by Sneden & Rowland, Greenpoint, L. I. Machinery constructed by Novelty Iron Works, New York. Superintendent of construction, Capt. Comstock. Route of service, Norwich to New York. Owners, Norwich and New York Transportation Co.

Hulls.—Length on deck, 300 ft. Breadth of beam, 37 ft. 6 ins. Depth of hold, 13 ft. Draft of water, 7 ft. 6 ins. Frames, strapped with diagonal and double laid iron braces. Tonnage, 1424 tons

Engines.—Vertical beam. Diameter of cylinder, 75 ins. Length of stroke of piston, 12 ft.

Boilers.—Two to each vessel—tubular—located on guards, and have one blower to each.

Paddle Wheels.—Diameter over boards, 37 ft. 8 ins. Material, wood.

Remarks.—These vessels are of white oak throughout. Each have patent water-tight compartments, which, although there are doors for passing in and out to the several saloons, can be closed, and made impervious to water in a moment of emergency. They have eighty-five state-rooms each, capable of accommodating two hundred and fifty-five persons. In addition to this, each boat has some three hundred other berths, so that six hundred passengers can, at any one time, find ample room and pleasant accommodations. Each state-room has double partitions. The precautions against fire are admirable and unique. No lights are allowed in the rooms, but the saloons are so brilliantly lighted that almost sufficient light strikes through the ground-glass panels of the doors for reading purposes. The saloons are all elegantly fitted up, and very large, the main upper saloon in each vessel being 225 feet in length.

The Steamer Stars and Stripes.—Hull built by C. Mallory, Mystic, Conn. Machinery constructed by C. H. Delamater, New York. In Government service.

Hull.—Length on deck, 150 ft. 6 ins. Breadth of beam, 34 ft. 6 ins. Depth of hold, 8 ft. Draft of water, 9 ft. Frames—molded, 13 ins.—sided, 8 ins.—apart at centres, 24 ins. They are securely fastened and strapped with iron braces, diagonally and double laid. Rig—three-masted schooner. Tonnage, 410 tons.

Engines.—Vertical direct. Diameter of cylinders, 26 ins. Length of stroke of piston, 2 ft. 6 ins.

Boilers.—One—tubular—located in hold, and uses a blower.

Propeller.—Diameter, 9 ft. Pitch, 16 ft. Material, cast iron.

Remarks.—This vessel is constructed of white oak, chestnut, &c., and put together in a masterly manner. She was originally intended for service on the route between New York and New Haven, but upon her completion she was purchased by the National Government, and since then has done excellent blockading duty upon the Southern coast.

The Steamer Santiago de Cuba.—Hull built by J. Simonson & Co., Greenpoint, L. I. Machinery constructed by Neptune Iron Works, New York. Superintendent of construction, Wm. D. Phelps. In Government service.

Hull.—Length of keel, 219 ft. Length on deck, 240 ft. Breadth of beam, 38 ft. Breadth over wheel houses, 52 ft. Depth of hold, 19 ft. 6 ins. Depth of hold to spar deck, 27 ft. Draft of water, 14 ft. Frames—molded, 15 ins.—sided, 18 ins.—apart at centres, 26 ins. Rig—Brigantine. Tonnage, 1650 tons.

Engines.—Vertical beam. Diameter of cylinder, 66 ins. Length of stroke of piston, 11 ft.

Boilers.—Two—flue. Length, 30 ft. Height, 12 ft. Breadth, 12 ft.

Paddle Wheels.—Diameter over boards, 29 ft. Length of blades, 9 ft. 6 ins. Number, 22. Diameter of shaft, 17 ins. Material, iron.

Remarks.—This vessel was intended as the pioneer of a line of steamers between the port of New York and St. Jago de Cuba, and was originally owned by Messrs. Valienti & Co., of the latter place. Her frames are of white oak, hacmetac, chestnut, &c., and square fastened, with copper and treenails. Her keel is of white oak, sided 12 ins. and moulded 15 ins.; the floor is solid to the floor timber-heads, fore and aft. Stem and stern posts of white oak; the inner stern-post and apron of live oak. Main keelson, 15 by 16 ins., and sister keelsons, two on each side, 12 by 12 ins. Bilge keelson, 12 by 12 ins., extending the whole length of the ship. The vessel is diagonally strapped with $4\frac{1}{2}$ and $\frac{7}{8}$ inch iron straps, from bilge to second deck, and has an iron strap of same dimensions running entirely around the ship inside. The planking is of oak. Each beam in the lower deck is well supported with bosom and lodging knees. Ceiling in lower hold—five strakes of 9 ins. thick, balance 7 ins. thick. All the arrangements of this steamer were such, that at the time she was finished she was surpassed by few steamships afloat.

The Steamer Paquette de Maule.—Hull built by Lawrence & Foulks, Williamsburgh, L. I. Machinery constructed by Neptune Iron Works, New York. Owners, Geo. K. Stevenson & Co., Valparaiso. Route of service, Valparaiso to Maule, coast of Chili.

Hull.—Length on deck, 165 ft. Breadth of beam, 29 ft. Depth of hold, 9 ft. Depth of hold to spar deck, 9 ft. Draft of water, 8 ft. 6 ins. Frames—molded, 12 ins.—sided, 6 ins.—apart at centres, 24 ins. These frames are square fastened with copper and treenails, and are strapped with diagonal and double laid braces, $4\frac{1}{2}$ by 7-16 ins. Rig—Brigantine. Tonnage, 400 tons.

Engines.—Vertical beam. Diameter of cylinders, 32 ins. Length of stroke of piston, 8 ft.

Boilers.—Two—flue—located in hold, and do not use blowers.

Paddle Wheels.—Diameter over boards, 24 ft. Material, wood.

Remarks.—This vessel is of white oak and locust, and constructed in the most thorough manner. She was the first vessel ever built in this country for the trade in which she is engaged, and this fact may be considered a recognition of the superiority of our Naval Architecture, as those steamers previously employed where the *Paquette de Maule* is running, have never fulfilled the requirements of the locality. The interests of the Chilian Government have heretofore secured the patronage of shipowners there for English shipbuilders, but by the untiring exertions of Messrs. Lawrence & Foulks, American skill achieves another triumph.

The Steamer Mercedita.—Hull built by Edward Lupton, Williamsburgh, L. I. Machinery constructed by Murphy, McCredy & Worden, New York. In Government service.

Hull.—Length at load line, 180 ft. Length on deck, 195 ft. Breadth of beam, 30 ft. Depth of hold, 11 ft. 3 ins. Depth of hold to spar deck, 19 ft. Draft of water 10 ft. Frames—molded, 14 ins.—sided, $7\frac{1}{2}$ ins.—apart at centres, 30 ins. Rig, Schooner. Masts, two. Bulkheads, two. Tonnage 840 tons.

Engines.—Vertical direct. Diameter of cylinders, 30 inches. Length of stroke of piston, 2 ft. 8 ins.

Boilers.—Two—horizontal tubular. Length, 16 ft. 6 ins. Breadth, 7 ft. 10 ins. Height, 8 ft. 4 ins. No. of furnaces, two to each. Breadth, 3 ft. 4 ins. Length of grate bars, 6 ft. 6 ins. No. of tubes above, 70. No. of flues below, 4. Internal diameter of tubes above, 4 ins. Do. flues below, 10½ and 19 ins. Length of tubes above, 10 ft. 6 ins. Do. flues below, 4 ft. Heating surface, 2500 sq. ft. Grate surface, 86 sq. ft. Diameter of smoke pipe, 4 ft. 4 ins.

Propeller.—Diameter, 10 ft. Pitch, 18 ft. No. of blades, 4. Material, cast iron.

Remarks.—This vessel was the first of four steamers intended to ply between Texas, New York, and Havana, but so soon as completed she passed into the hands of the United States. She was constructed with a view to attain great strength and speed. She is built of white oak, hacmetac, and chestnut, and is ceiled with yellow pine. Instead of using iron straps as braces for her frames, she has every four feet over her ceiling diagonal oak braces, 9 by 2½ inches, making five inches in thickness, running from upper deck clamp to fifteen inches below floor heads, each intersection being bolted with iron, and all the treenails passing through the ship and wedging in these braces—thus forming, it is asserted, a greater strength than was ever before attained in a vessel of her class.

The Steamer Shantung.—Hull built by Thomas Collyer, New York. Machinery constructed by Neptune Iron Works, New York. Owners, Everitt & Co. Route of service, coast of China.

Hull.—Length on deck, 150 ft. Breadth of beam, 25 ft. 6 ins. Depth of hold, 10 ft. Depth of hold to spar deck, 17 ft. 6 ins. Draft of water, 7 ft. Frames—molded, 12 ins. —sided, 5 and 6 ins.—apart at centres, 26 ins. They are square fastened with copper and treenails, and are braced with iron straps, diagonally and double laid, 3½ by ⅜ ins., extending entirely around them. Rig, Schooner. Tonnage, 520 tons.

Engines.—Vertical beam. Diameter of cylinder, 36 ins. Length of stroke of piston, 10 ft.

Boilers.—One—flue—located in hold, and uses a blower.

Paddle Wheels.—Diameter over boards, 22 ft. Material, iron.

Remarks.—This steamer is constructed of white oak and chestnut, and put together in a masterly manner. Her model is without fault. The reputation which Mr. Collyer achieved in China for building steamships, was surpassed by no other Contractor. He sent to the seas of that empire some eight or ten vessels, all of which have beat, in many an exciting race, the boasted steamers of England.

The Steamer Flambeau.—Hull built by Lawrence & Foulks, Williamsburgh, L. I. Machinery constructed by Henry Esler & Co., Brooklyn, L. I. In Government service.

Hull.—Length on deck, 185 ft. Breadth of beam, 30 ft. Depth of hold, 11 ft. Depth of hold to spar deck, 18 ft. Draft of water, 10 ft. 6 ins. Frames—molded, 14 ins.—sided, 8 ins.—apart at centres, 30 ins. These frames are square fastened with copper and treenails, strengthened in the best possible manner by iron straps, diagonally and double laid, 4 by ½ in., extending around them. Rig, Brigantine. Tonnage, 791 tons.

Engines.—Vertical beam. Diameter of cylinder, 50 ins. Length of stroke of piston, 5 ft.

Boilers.—Two—tubular. Located in hold.

Propeller.—Diameter, 10 ft. Pitch, 18 ft. No. of blades, 4. Material, cast iron.

Remarks.—This steamer was built for Messrs. P. S. Forbes & Co., and was intended for service on the coast of China, but owing to her excellent construction she was taken by the National Government at the period of her completion. She is built in a masterly manner, of white oak, chestnut, &c., and is of beautiful model. The builders of her machinery had two objects in view at the time of its construction, viz: great strength and speed, and the trips she has made have proved very conclusively to them that they have succeeded even beyond their most sanguine expectations.

The Steamer Honduras.—Hull built by Thomas Collyer, New York. Machinery constructed by Neptune Iron Works, New York. Owners, L. H. Ackerman and others. Route of service, Honduras to Cuba.

Hull.—Length on deck, 150 ft. Breadth of beam, 26 ft. Depth of hold, 10 ft. Draft of water, 7 ft. Frames—molded, 12 ins.—sided, 5 and 7 ins—apart at centres, 28 ins. These frames are square fastened with copper and treenails, and have iron straps, diagonally and double laid, 3½ by ⅞ ins., running around them. Rig, Schooner. Tonnage, 375 tons.

Engines.—Vertical beam. Diameter of cylinder, 36 inches. Length of stroke of piston, 8 ft.

Boilers.—One—flue—located in hold, and has no blower.

Paddle Wheels.—Diameter over boards, 22 ft. Material, iron.

Remarks.—This vessel is built of white oak and chestnut, and has all the requirements for an excellent sea-going steamer.

The Steamer Constitution.—Hull built by Wm. H. Webb, New York. Machinery constructed by Novelty Iron Works, New York. Superintendent of construction, Capt. Francis Skiddy. Commander, A. T. Fletcher. Owners, Pacific Mail Steamship Co. Route of service, San Francisco to Panama.

Hull.—Length on deck, 333 ft. Do. over all, 364 ft. Breadth of beam, 44 ft. Depth of hold, 23 ft. 6 ins. Do. to spar deck, 31 ft. 6 ins. Draft of water, 20 ft. Frames—molded, 15 ins.—sided, 18 ins.—apart at centres, 36 ins. These frames are fitted in solid, and have iron straps, diagonally and double laid, 4½ by ⅞ ins., running around them, securing them in the best possible manner. Rig, Brig. Tonnage, 3446 tons.

Engines.—Vertical beam. Diameter of cylinder, 105 ins. Length of stroke of piston, 12 ft. Diameter of piston rod, 11½ ins. Diameter of crank pin journal, 14 ins. Length of do., 18 ins. Diameter of beam centre journals, 15½ ins. Length of do. 21 ins.

Boilers.—Four—flue. Diameter of shell, 13 ft. 3 ins. Length of boilers, 32 ft. Height 14 ft. Diameter of steam drum, 8 ft. Diameter of smoke pipe, 7 ft. Height of do. 41 ft. Five cylindrical furnaces in each boiler—diameter, 40 ins. Fire surface in each boiler, 3300 sq. ft. Grate surface, do., 115 sq. ft.

Paddle Wheels.—Diameter of water wheel outside of buckets, 40 ft. Length of buckets, 18 ft. Width of do., 24 ins. Diameter of water wheel shaft journal, 22 ins. Length of do., 30 ins.

This steamer has Sewell's surface condenser, fitted with 5500 brass tubes, 9 ft. long, the condensing of which equals 8000 sq. ft.

Remarks.—This vessel is built of live oak, chestnut, hacmetac, &c. She embraces all the modern improvements for securing great strength, safety and comfort. For securing proper ventilation, the state-rooms are very large, and lattice-work is secured in every position to insure a full and free circulation of air in all the apartments. Imperfect ventilation has been the prevailing defect in former Pacific steamers. Such evils are remedied in the *Constitution*. The hatches and all the important openings are about double the size of those in most steamers, and ventilating hoods are applied to operate alike to atmospheric siphons to remove the hot air, and take in a constant supply of cold air. Two large blowers are also used for ventilation.

The Steamer James F. Freeborn.—Hull built by Lawrence & Foulks, Williamsburg, L. I. Machinery constructed by Fletcher, Harrison & Co., New York. Commander, Capt. O. Morrell. Owners, Richard M. Squires and others.

Hull.—Length on deck, 155 ft. Breadth of beam, 26 ft. Depth of hold, 9 ft. 8 ins. Draft of water, 5 ft. 6 ins. Frames—molded, 13 ins.—sided, 6 ins.—apart at centres, 26 ins. Tonnage, 380 tons.

Engines.—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke of piston, 9 ft.

Boilers.—One—flue. Diameter of shell, 10 ft. 3 ins. Breadth of front, 11 ft. Length, 23 ft. Steam chimney, 50 ins. internal, and 86 ins. external diameter. It has two furnaces, 7 ft. 6 ins. in length, and is fitted with 26 flues. Heating surface, 1805 sq. ft. Grate surface, 75 sq. ft. There are 23 sq. ft. of heating surface to each cubic foot of cylinder, and 24 ft. of heating surface to one of grate.

Paddle Wheels.—Diameter, 22 ft. Face, 8 ft. Dip, 38 ins. Have 22-inch buckets.

Remarks.—This vessel is built of oak, chestnut, and hacmetac; frames double throughout; filled in solid for 50 feet from the stern. Keelsons of yellow and white pine, 7 in number, 14 by 14 inches. Bilge strakes of oak and yellow pine, 4 in number, 5 ins. thick, 12 ins. wide each. Ceiling throughout of yellow pine, 3 ins. thick; oak strings 4½ by 14 ins. Bottom planks of oak, 3 ins. thick. Deck beams 6 by 6 ins., of yellow pine. Hanging knees in hold, of hacmetac. Stevens' cut-off is applied to the engine. B.

New York, November 15, 1862.

(To be Continued.)

Of the Earthquake-Wave Experiments made at Holyhead.

By Robert Mallet, Esq., C. E., F. R. S.

(Abstract.)

This communication contributes the sequel of the author's "Report on Earthquake-Wave Experiments" (made at Holyhead), as published in part 3 of the "Philosophical Transactions" for 1861. At the conclusion of that paper the author expressed his hope of being able soon to lay before the Royal Society some experiments for the determination of the modulus of elasticity of perfectly solid portions of both the slate and the quartz rock formation through which his wave-transit experiments had been made at Holyhead, with a view to throw light

upon the relations between the theoretic velocity of transmission (if the rocks were all solid and homogeneous) and the actual velocity as determined by experiment.

He has now determined the elastic modulus for both rocks, and for each rock in two directions, viz: parallel to and transverse to its lamination; and he has extended his determinations to specimens of each rock of maximum and of minimum compactness and hardness, so that the series of experiments upon the compressibility of these rocks (from which the modulus is derived) assumes the following divarication, viz. :—

Slate rock . . { Hardest . { B. Parallel to laminæ, Table 2. / A. Transverse to laminæ, Table 1. } Softest . . { F. Parallel to laminæ, Table 6. / E. Transverse to laminæ, Table 5. }

Quartz rock. . { Hardest . { D. Parallel to laminæ, Table 4. / C. Transverse to laminæ, Table 3. } Softest . . { H. Parallel to laminæ, Table 8. / G. Transverse to laminæ, Table 7. }

Involving thus eight distinct series of experiments.

The compressions were conducted at the Royal Arsenal, Woolwich, by the aid of the excellent American machine belonging to the Royal Gun-factories, permission to use which was accorded to the author.

The specimens of rock submitted to pressure were all equal cubes of 0·707 inch on the edge, presenting thus a surface on each side of 0·5 square inch—a dimension presenting facilities for tabular reduction, &c.

The cubes were cut from the chosen rock specimens (selected with care as fairly representative) by means of the lapidary's wheel, and had opposite faces rigidly parallel and equal.

The pressures advanced by 1000 lbs. per square inch of surface, from zero up to the crushing point of the specimen; and at each advance the actual compression of the column of rock was measured by instrumental arrangements that admitted of reading space to ·0005 of an inch. The results are given in tables numbered 1 to 8, referred to above, and these are compared in two tables numbered 9 and 10.

The following are the mean compressions for each 1000 lbs. per square inch :—

Slates.				Quartz.			
A.	B.	E.	F.	C.	D.	G.	H.
inches. ·000627 up to 23,000 lbs.	inches. ·0025000 up to 26,000 lbs.	inches. ·0039144 up to 14,000 lbs.	inches. ·0037000 up to 7000 lbs.	inches. ·0007085 up to 35,000 lbs.	inches. ·0010947 up to 19,000 lbs.	inches. ·0014666 up to 12,000 lbs	inches. ·0172666 up to 6,000 lbs.

Crushing usually took place at 1000 to 2000 lbs. additional pressures beyond the above limits, up to which the compressions were tolerably uniform.

The discussion of these tables fully presents some interesting and novel results.

Generally the quartz rock is less compressible than the slate; the softest quartz, however, is much more compressible than the softest slate in a direction parallel to the lamination of both. In this direction also the hardest slate is more than double as compressible as the hardest quartz. Transverse to the lamination, however, both the hardest slate and quartz have nearly the same co-efficient of compressibility, which is very small for both. In the latter direction also the *softest* slate and quartz have almost the same co-efficient, but one about *four times* as great as for the *hardest* like rocks.

The author points out several conclusions of much interest deducible from these experiments as to the physical and geological conditions under which these rocks were formed and consolidated. The compression by natural forces has already been greatest in directions transverse to the lamination. The great compressibility in the opposite directions, or parallel to the lamination, appears to arise chiefly from the mass of the rock being made up of minute wedge-shaped mineral particles, deposited all with their largest dimensions on the plane af lamination, and so acting on each other like wedges.

Some curious circumstances in the mode of giving way of the rocks under pressure are shown by the author to be probably connected with their mass being formed of an aggregate of several simple minerals.

He points out the great differences in wave-transmissive power in directions transverse to and parallel to the lamination which these experiments disclose. The specific gravities of the several specimens of rock are then given, to enable the modulus of elasticity to be obtained in feet, and the general results of the experiments are comprised in the following table (p. 48):—

The author then proceeds to apply these results to the comparison of the theoretic and actual transit-periods of the wave of impulse.

The general expression for elastic wave-propagation in a homogeneous medium may be expressed by an equation of the form

$$v = \sqrt{gL} = 8{\cdot}024\sqrt{L},$$

where L is the modulus of elasticity in feet. Where, from want of homogeneity or shattering, &c., as found in nature, the experimental value of v differs from this, we may express it by the same form of equation,

$$v' = a\sqrt{L},$$

the co-efficient a having to $\sqrt{2g}$ the rate that the actual bears to the theoretic value of v.

He then determines the value of a for three of his mean experimental transit-velocities at Holyhead, and obtains as follows:—

Feet per side.	
$v' = 1089$	$a = 0{\cdot}637$
$v' = 1352$	$a = 0{\cdot}791$
$v' = 1220$	$a = 0{\cdot}714$

Holyhead Rock Compression.

General results reduced, modulus of cohesion and of elasticity, &c.—Slate and Quartz.

No.	Class of rock, and direction of pressure in relation to structure.	Co-efficient of compression on unit surface for 1000 lbs.	Elastic limit for compression.	Crushing load on the unit of surface.	Modulus of cohesion (compression).	Modulus of elasticity.	Modulus of elasticity.	Co-efficient T_r.
		inches.	lbs.	lbs.	feet.	lbs.	feet.	
1	Slate *hardest across* lamination.	·0006217	22,000	24,000	20,014	8,042,464	6,706,524	1·2432
2	Quartz *hardest across* lamination.	·0007085	32,000	37,000	32,095	7,057,163	6,121,758	2·1830
3	Slate *hardest parallel* to lamination.	·0025000	18,000	27,000	22,515	2,000,000	1,667,778	5·6241
4	Quartz *hardest parallel* to lamination . . .	·0010947	17,000	20,000	17,349	4,567,461	3,962,013	1·8240
5	Slate *softest across* lamination.	·0039144	12,000	15,000	12,586	1,277,335	1,071,769	4·8930
6	Quartz *softest across* lamination	·0014666	11,000	14,000	12,158	3,409,246	2,960,699	1·7108
7	Slate *softest parallel* to lamination	·0037000	6,000	9,000	7,552	1,351,351	1,133,874	2·7747
8	Quartz *softest parallel* to lamination	·0172666	7,000	8,000	6,948	289,576	251,477	11·6112
	Calculated Means.							
9	Slate, mean for hard and soft *across* lamination.	·0022680	17,000	19,500	16,311	2,204,585	1,844,069	3·6855
10	Quartz, mean for hard and soft *across* lamination.	·0010885	16,500	25,500	22,132	4,597,701	3,990,455	2·3103
11	Slate, mean for hard and soft *parallel* to lamination	·0031000	12,000	18,000	15,056	1,612,903	1,349,145	4·6494
12	Quartz, mean for hard and soft *parallel* to lamination	·0091806	12,000	14,000	12,151	544,627	472,684	10·7100
	Calculated Means of Means.							
13	Slate, hard and soft, mean for both directions (Nos. 9 and 11)	·0026840	14,500	18,750	15,684	1,862,880	1,566,541	4·1914
14	Quartz, hard and soft, mean for both directions (Nos. 10 and 12).	·0051340	16,750	19,750	17,141	973,899	845,252	8·4490
15	General mean for slate and quartz, hard and soft, and in both directions (Nos. 13 and 14).	·0039090	15,625	19,250	16,398	1,279,099	1,089,615	6·2697

The actual velocity of wave-transmission in the slate and quartz rocks, taken together, was to the theoretic velocity due to their materials, if perfectly solid,

$$a : \sqrt{2g}, \text{ or as } 1{\cdot}00 : 8{\cdot}89 ;$$

so that nearly eight-ninths of the full velocity of wave-transmission due to the solid material is lost by reason of the heterogeneity and discontinuity or shattering of the rocky mass as it is piled together in nature.

The author then shows that were the rocks *quite solid*, the velocity of wave-transmission would be—

Mean of slate and quartz transverse to lamination $v = 13{,}715$ feet per second.

Mean of slate and quartz parallel to lamination $v = 7659$ feet per second.

This difference is probably reversed *in nature* by reason of the greater discontinuity in the former direction. The author then shows that his results, which appear at first sight to conflict with those of an analogous character obtained by Helmholtz and others for wood, in the three principal directions of its section, are strictly in accordance and analogy with the results of these experimenters.

The author concludes by deducing some conclusions as to the bearing power, safe load, and proper direction as to lamination when exposed to pressure, of these rocks, of a practical character, and valuable to the civil engineer or architect.

Proc Royal Society, May 8, 1862.

On Steam-Boiler Explosions.

From the London Chemical News, No. 144.

The Decomposed Steam Hypothesis.—The unsatisfactory results generally obtained by those who have sought to decompose water by heat on a large scale, with the view of applying its elementary gases separately, do not appear to have prevented the occasionial adoption of the hypothesis that, in certain cases, all the steam contained within a boiler is decomposed, and its hydrogen (by some means not easily explained) exploded with great violence. That steam, passed over pure metallic iron heated to redness, is decomposed, is perfectly true, although the iron must retain all the oxygen separated in the operation. With oxidized iron, however, the process of decomposition cannot be continued. This is, we believe, a chemical fact of which there can be no dispute. To decompose 1 lb. of water (or steam, which is chemically the same substance) 14·2 oz. of oxygen must be fixed by the iron, and only 1·8 oz. of hydrogen will be set free. This large proportion of oxygen, absorbed by only a few square feet of over-heated surfaces, would soon form an oxide of iron of sufficient thickness to arrest all further decomposition, and all the hydrogen up to that time disengaged would not amount, perhaps, to 1 lb. in weight. By itself, or mixed with steam, hydrogen cannot be exploded, nor even ignited. It will extinguish flame as effectually as would water.

Upon this subject we may refer to a report made by Professor Faraday in May, 1859, to the Board of Trade upon the liability to accident consequent upon the introduction of an apparatus for superheating steam on board the Woolwich steamboats. In this apparatus the steam was carried in iron pipes immediately through the furnace, and in contact with the incandescent fuel. Professor Faraday, after having examined the apparatus at work, says:—

"I am of opinion that all is safe, *i. e.*, that, as respects the decomposition of the steam by the heated iron of the tube and the separation of hydrogen, no new danger is incurred. Under extreme circumstances the hydrogen which could be evolved would be very small in quantity—would not exert greater expansive force than the steam—would not with steam form an explosive mixture—would not be able to burn with explosion, and probably not at all if it, with the steam, escaped through an aperture into the air, or even into the fire-place.

"Supposing the tubes were frequently heated over much, a slow oxidation of the iron might continue to go on within; this would be accompanied by a more rapid oxidation of the exterior iron surface, and the two causes would combine to the gradual injury of the tube. But that would be an effect coming under the cognizance of the engineer, and would require repair in the ordinary manner. I do not consider even this action likely to occur in any serious degree. I examined a tube, which had been used many months, which did not show the effect; and no harm or danger to the public could happen from such a cause."

Professor Taylor, of Guy's Hospital, reported in part, as follows, upon the same apparatus:—

"It is true that steam passed over pure metallic iron heated to redness (1000°) is so decomposed that the oxygen is fixed by the iron while hydrogen gas is liberated. This chemical action, however, is of a very limited kind. The surface of the iron is rapidly covered with a fixed and impermeable layer of the magnetic oxide of iron, and thenceforth the chemical action is completely arrested. If the interior of an iron pipe has been already oxidized, by passing through it, while in a heated state, a current of air, there will be no decomposition of steam during its passage through it. If the interior of an iron pipe were not thus previously oxidized, it would speedily become so by the oxygen derived from the air, which is always mixed with steam. Hence, chemically speaking, under no circumstances, in my opinion, would any danger attend the process of superheatiug steam as it is conducted under this patent. It is proper, also, to state that hydrogen is not explosive, but simply combustible, and assuming that it was liberated as a result of the decomposition of superheated steam, its property of combustibility would not be manifested in the midst of the enormous quantity of aqueous vapor liberated with it and condensed around it. There could be no explosion, inasmuch as hydrogen, unless previously mixed with oxygen, does not explode; and oxygen is not liberated but actually fixed by the iron in this process. It is a demonstrable fact that the vapor and gas evolved under the form of

superheated steam, tend to extinguish flame and to prevent combustion from any other cause."

Professor Brande, in a report made by him to the patentees of the same apparatus, observes:—

"In reference to the question which you have submitted to me, respecting the possible or probable evolution of hydrogen gas and consequent risk of explosion in the processes, and by means of the apparatus which you employ for the production of superheated steam, I am of opinion that there can be no danger from such effect, that the temperature to which the iron pipes connected with your boiler are raised, and the extent of the iron surface over which the steam passes, are insufficient for its decomposition; and that if the temperature of the pipes were even raised considerably beyond that which you employ, or would be able to attain, a superficial layer of oxide of iron would line the interior of the heated pipes, and so prevent any continuous decomposition of water. Effectually to decompose steam, by passing it over iron, it is necessary that a very extended surface of the metal (as in the form of thin plates or iron turnings) should be used, and that the temperature should be continuously maintained at a bright red heat, namely, at a temperature considerably above 1000° Fah. I have read Dr. Taylor's report, and entirely agree with the inferences he has drawn as to the absence of danger from the evolution of hydrogen gas in practically carrying out your process for the production and application of superheated steam."

The practical conclusions upon this subject are the following:—1. Decomposition cannot possibly occur, to any considerable extent, under any circumstances arising in the working of ordinary steam boilers. 2. If it did occur, the hydrogen thus liberated would have no access to oxygen, without which it could neither inflame nor explode. 3. Even if oxygen were present, the presence of steam would prevent ignition. 4. If oxygen were present, and no steam existed in the boiler, the hydrogen would only inflame and burn silently as fast as it was produced, the heat for ignition being supposed to come from a red-hot plate. Under these accumulated impossibilities of violent explosive action, the explanation of boiler explosions by the decomposition of steam is without any support whatever.

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*On Boiler Deposits and Incrustations.**

From the Practical Mechanic's Journal, Sept. 1862.

In presenting to the Institution of Civil Engineers of Ireland the following translation of M. Couste's Memoir on Boiler Deposits, by Mr. Robt. Trefusis Mallet, now employed as a resident engineer upon the Great East Indian Railway, Bengal, it may be desirable to preface it by a brief statement of the principal conditions that affect questions of the nature, formation, or prevention of boiler deposits.

The importance of the subject to mechanical engineering, and to the public, cannot be overrated. The efficient exclusion of deposits

* From a Memoir about being published in the Transactions of the Institution of Civil Engineers of Ireland.

and incrustations from innumerable land boilers of Great Britain alone, would involve the economization of millions of tons of fuel—the preservation of many lives periodically destroyed by explosion, often traceable to this as one in the train of causes; while if perfected in marine boilers, it would revolutionize much of our steamship machinery. That such possible results are recognised, is proved by the fact that more than seventy patents encumber the records at this moment, for methods presumed to mitigate or to prevent deposit or incrustation of boilers; yet amongst these it may be affirmed that there is not even one that fully answers its purpose, while the great mass consist of mere "nostrums," that only prove the general ignorance of the conditions in the problem by the inventors and by the public. I do not, therefore, suppose that any apology is required from me on the part of the translator of M. Couste's most valuable memoir, although its first appearance in its original language dates some years back; for I am myself aware that, owing probably to its having been inaccessible except in a foreign tongue, it has remained up to the present time almost completely unknown to British mechanical engineers. Yet it contains a rigorous investigation of some of the most important conditions upon which depend the *only* method so far effective for the prevention of boiler deposits, namely—the continuous removal of determinate volumes of the heated fluid, so as to avoid saturation and deposition, whether partial or total.

M. Couste touches but slightly upon the chemical or mineralogical parts of the subject; he deals principally with its thermic and dynamic relations.

I propose, therefore, to preface the translation of his memoir by passing the former very briefly in review, and referring as briefly to some of the modes, patent or otherwise, proposed as remedies, and chiefly dependent on chemical relations.

Exclusive of "mine waters," or other natural waters, mineralized or polluted, and hence everywhere to be shunned for feeding boilers, and therefore rather beside our subject, the natural waters with which steam boilers are supplied for evaporation, may be divided into—1st, Fresh water; 2d, Sea water; and the questions for the practical engineer refer to the nature of their solid contents, the causes and order of deposit of these, and to the action of their solid contents upon the boiler.

The primary effects of the solid contents of the water ceasing to remain in solution as when introduced to the boiler are, 1st, Deposition, and at a further and more or less prolonged stage, Incrustation; i. e., the induration of the previously unintegrated precipitate, whether morphous or finely crystalline.

And the immediate consequences are—

1. Interference with the full functions of the boiler in supplying steam.
2. The promotion of its destructive action by the fire and flame of the fuel upon its shell.

While the remoter consequences is the danger of explosion induced, which becomes extreme when the deposit is thick and diffused.

The destructive re-action upon the boiler again is two-fold—

1. Mechanical.—The deposit or incrustation preventing the free passage of heat to the water through the shell of the boiler, causing waste of fuel and overheating of the boiler, and interfering (in various constructions of boiler) with the free circulation of the fluid, upon which the rapid taking up of heat by it so much depends.

To treat fully of the last would involve the passing in review a great number of different forms and constructions of boiler, and be quite beyond our scope here.

It is enough to say, that obviously boilers with intricate interior construction, closely placed tubes and water spaces, &c., will be most liable, *cæteris paribus*, to this injurious result.

2. Chemical.—Corrosion and destruction of the metal of the boiler due to the action of more concentrated saline matter, soluble and insoluble; and to that of the air and gases of the furnace acting on the metal brought to a higher temperature.

Both effects under this head are modified by the nature of the metal of which the boiler is constructed; and practically our steam boilers may be classed as either of iron or of copper, or of some few of the alloys of the latter.

Boilers of iron are most acted on by air and water, and by some of the saline contents of fresh and sea water when concentrated; while copper boilers (once strongly advocated for marine purposes) are more affected by the oxidized sulphur of the coal, by the ammonia evolved from its combustion, and by the oily acids of the grease pumped into and spread about the boiler. It should be remarked in passing, however, that when sulphurous fuel is burnt at an intensely high temperature in direct contact with the boiler shell, iron is acted on with great rapidity (whether with or without internal deposits), and apparently by the direct formation, at the external surface of the iron shell, of successive thin coats of bi-sulphuret of iron; hence it is, as one cause, that copper fire-boxes possess their durability in locomotive fire-boxes. There are other and independent reasons for this durability, however.

In the class of natural fresh waters, the substances *most commonly* found dissolved are lime, soda, iron, magnesia, potass, alumina, and silica (the relative quantities being *usually* in the order here set down), and in combination with oxygen, chlorine, occasionally with oxidized nitrogen, in the form of nitrates and carbonic acid.

Organic compounds of carbon, hydrogen, and nitrogen, are also often present. Besides these, natural fresh waters contain air in solution, often with excess of oxygen, carbonic acid, uncombined with solid bases, and more rarely sulphuretted hydrogen.

The analysis of Thames water by Dr. R. D. Thompson, as supplied by some of the London Water Companies, may be taken as a type

of our common hard waters, receptive (more or less) of putrescible matter—and hence of such as most commonly supply our land steam boilers.

In this city (Dublin) the well waters from the limestone gravel are much more rich in sulphate of lime, which is still more the case in the waters, for example, of the Paris Gypseous Basin. Hence, in so far, the latter are both worse than the London water as steam boiler supply—sulphate of lime forming, in fact, both in land and marine boilers, the most insoluble and intractable portion of any deposit formed.

The solid matters contained in one imperial gallon of Thames water, according to the above chemist, are—

THAMES WATER

Chloride of Sodium,	16·00 grains.
Sulphate of Potass,	2·41
Chloride of Magnesium,	2·10
Carbonate of Magnesia,	0·50
Chloride of Calcium,	2·11
Nitrate of Lime,	0·07
Sulphate of Lime,	3·18
Carbonate of Lime,	10·70
Oxide of Iron and Alumina,	0·46
Silica,	0·24
Organic Matter,	3·56
Total,	41·33

A boiler fed with such water (and this is not a remarkably impure one), a locomotive, for example, blowing off into steam 1000 gallons per hour, would, at the end of 350 hours, if no deposit or solid matter were blown out or otherwise removed, contain nearly a ton of sediment.

An imperial gallon of water is capable of holding dissolved when cold (60° Fahr.), and when boiling in free air (212° Fahr.), the following weights nearly, of the more important of the preceding salts:—

	At 60° Fahr.	At 212° Fahr.
Carbonate of Lime,	merely traces.	merely traces.
Silica,	70 grains.	"
Sulphate of Lime,	170 grains.	"
Carbonate of Magnesia,	3·25 oz.	"
Sulphate of Potass,	10 oz.	40 oz.
Chloride of Sodium,	32 oz.	32 oz.
Chloride of Magnesium,	266 oz.	580 oz
Nitrate of Lime,	500 oz.	" ?
Chloride of Calcium,	540 oz.	unlimited.

It will thus be evident that the order of depositions, as the water in the boiler becomes concentrated, is—

1. Carbonate of Lime,
2. Sulphate of Lime,
3. The Salts of Iron, as Basis or Oxides, and some of those of Magnesia,
4. The Silex and Alumina, usually with more or less of the Organic Matter,
5. Common Salt.

The carbonate of lime sometimes deposits as an amorphous mass, like hard, fawn-colored chalk, but much more usually, especially in high pressure boilers, precipitates in the crystalline form, as arragonite

(one of the dimorphous forms, of which calc spar is the other). The sulphate of lime falls as amorphous gypsum most commonly, but not unfrequently in small crystals of hydrated gypsum, (the water combined in unusual proportions, as in those discovered, some years ago, by the late Professor Johnson of Durham, Reports Brit. Ass.) segregated or coherent as a hard crust—which latter forms the worst form of "boiler scale"—and when long exposed to high temperature, becomes changed to anhydrite, with the form of crystal, and hardness of the natural mineral.

Recurring now to marine boilers, or those fed with sea or salt water—our second class,

We may take Bouillon La Grange and Vogel's analysis of the ocean water outside Bayonne, in the Gulf of Gascony, as a type of sea water. The total saline contents in a cubic foot of sea water varies, but within limits, in the ocean, and all the great tracks of navigation, that may be practically neglected. The freshest water is probably that of the Baltic, and upper part of the Black Seas—sp. gr., about 1024. The upper limit of salt is in the water of the Dead Sea—sp. gr., 1240 nearly.

The following are the solid contents of 100 parts of the Gulf of Gascony:—

Chloride of Sodium,	2·510
Chloride of Magnesium,	0·350
Sulphate of Magnesia,	0·578
Carbonate of Lime and of Magnesia,	0·020
Sulphate of Lime,	0·015
Carbonic Acid (in solution),	0·023
	3·496

The essential solid elements, as regards our subject, are the lime, sea salt and magnesia, in combination with sulphuric acid and chlorine, and very often in practice that which analysis does not show, a vast amount of suspended muddy water, which is pumped with the water into the boilers, as in the Ganges, British Channel, &c.

In minute quantity sea water, however, also contains potass, alumina, and various metals, with bromine and iodine.

The following table, by Berthier, shows the order and proportionate deposition of solid matter upon concentration, by boiling off steam from sea water, per 100 parts.

Saline Matter.	A Sea Water. sp. gr., 1·0278.	B Ditto. Concentrated sp. gr., 1·140.	C Ditto. Concentrated sp. gr., 1·220.	D Ditto. Concentrated Salt nearly Deposited.
Chloride of Sodium,	2·50	16·00	25.50	20·80
Chloride of Magnesium,	0·35	0·46	1·07	4·85
Sulphate of Magnesia,	0·58	0·80	1·48	9·50
Carbon. of Lime and Magnesia,	0·02	0·00	0·00	0·00
Sulphate of Lime,	0·01	0·00	0·00	0·00
Sulphate of Soda,	0·00	2·65	2·81	0·00
Water,	95·54	79·79	69·14	64·85
	100	100	100	100

Thus when sea water is boiled down so that the water is only about 65 per cent.—*all* the salts of lime and magnesia—the whole of the sulphate of soda formed, and a large proportion of the sea salt have been deposited, and these constitute the tough and hard cake of salt, with imperfect crystallization, arranged perpendicularly to the heated surface, *i. e.*, the shell, that is so destructive and inconvenient in marine boilers.

In the state of concentration of D, the sea water is a strong brine, with a high boiling point. The elevation of the latter is shown by the following table, from Faraday's past experiments:—

Volume of Sea Water.	Boiling Temper. at 30° Barom.	Saline Matter in 100 parts.	Nature of the Deposit.
1000	214° Fahr.	3·0	None.
299	217° "	10 0	Sulphate of Lime.
102	228° "	29·5	Common Salt.

Thirty-seven parts of common salt saturate 100 of water, at all temperatures, if both be pure, according to Fuchs, but when the other contents of sea water are present, 36 parts saturate at 226° Fahr., and 30 parts at 228°. The loss of solubility *augmenting* with the temperature, hence 10 volumes of sea water concentrated to one, becomes, in part, saturated brine.

M. Couste has noticed also analogous facts with reference to the sulphate of lime.

We may now pass briefly in review the several methods that have been proposed or tried for mitigating or preventing these injurious deposits. To attempt to go through these *seriatim*, or even the patented ones only, would be impossible, and a bootless labor. They may be classed, however, under the following heads:—and first, as respects land boilers evaporating fresh water.

1. Filtration of the water—an obvious preliminary that should invariably be adopted when the water contains suspended mineral matter, but which does not affect dissolved salt, for, although long continued filtration and moving contact with solids, such as flint pebbles, will deprive water even of some of its soluble contents, the process carried to this extent is too costly for our purpose.
2. The application of collecting vessels to the boilers. These are of two sorts. A, external close vessels, heated by otherwise waste flue heat, into which the feed water of the boiler is primarily admitted, and passes thence to the boiler.

   The function of such a vessel is that the lime held in solution as bi-carbonate, by the excess of carbonic acid dissolved in the water, is partially precipitated in the vessel as carbonate, the carbonic acid being driven off by the heat.

   This constitutes Brunton's patent for sediment vessels.

   It has also been proposed to adopt Dr. Clarke's water purifying process to the feed water entering boilers, and to precipate the bi-carbonate of lime by adding measured volumes of

lime water, so as to form proto-carbonate. Like all other devices that aim at changing the water by chemical means, however, it is too delicate in application, and any excess of lime would obviously only add to the evil.

I may state here, upon the authority of my own researches of past years, that the carbonic acid is evolved, and the carbonate of lime begins to deposit, as soon as the feed water is heated to 190° Fahr.—(Reports Brit. Ass. Reports on Iron Corrosion.)

B, Internal collecting vessels, proposed by many separate inventors long since, and patented several years ago by Mr. Scott. These contrivances depend upon the fact that the solid matter when first separated from solution, and floating about in the agitated boiling water of the boiler, will find a resting place, and precipitate, *i. e.*, collect, in any part of the boiler, where we may provide for it a quiet spot, free from agitation of the water.

Hence, if a narrow necked vessel, as a bottle or pan, be placed within or hung up in a steam boiler, the water, though at 212° within it, does not circulate in brisk currents, and gradually the floating particles, as they pass its mouth, fall into this collecting vessel, deposit, and never return from it. This does in reality constitute one of the most efficient means known of collecting the deposit to one point, so as to preserve the rest of the boiler surface free, comparatively. It can be readily removed from the collecting vessel.

To this division belongs also the plan often adopted, of putting balls of wood, or brick, or stone, &c., into the boiler, which roll about with the agitated water, and segregate some of the deposit in coat after coat upon their surfaces. This notion is very ancient, and has been known in domestic life—housewives putting a boy's marble into their teakettles with a similar object.

The two methods, A and B, may be combined; and I have in my own practice found the combination advantageous—an external sediment vessel heated by the waste flue heat receiving the feed water, and in it the greater part of the carbonate of lime is left; while internal collecting vessels in the boiler receive the greater part of the remainder, in combination with the sulphate of lime. This method also, though long previously in use, has been patented by Taylor.

3. The addition of foreign materials to the water of the boiler, with a view to prevent the aggregation of the particles of the deposit, and their adherence to the walls of the boiler.

The substances proposed with this end in view are numerous.

Potatoes, oatmeal, bran, sawdust, molasses, coal-tar, charcoal dust, smiths' dust,—*i. e.*, finely divided coke and ashes,—coal ashes, plumbago, soap, tallow, and many others have been added in more or less bulk to the water in the boiler before closing the main lid after cleaning. All of these, and more especially such matters as potatoes or sawdust, possess some power of subdividing and making more friable

calcareous deposits, and are not without some use when much sulphate of lime is present in the water, as they greatly interfere with its crystallization into massive crusts; but their effort is temporary, and all such additions are attended more or less with the serious evils of "priming," *i. e.* water being driven over with the steam into the steam pipes and valves of the engine from the boiler, and with it solid matter, which chokes the passages, spoils the valve faces, &c. To this class of mitigants belongs the useless and expensive nostrum long in use "by authority" in the Royal Navy, of coating the whole inside shell of the boiler (in steam ships) with tallow and black lead mixed together, under the notion that it prevented the adhesion of deposited salt. It is believed that this is long discontinued.

4. In addition to the water in the boiler, or to the feed water entering it, of chemical agents intended to render the less soluble salts in the water more soluble, and therefore less capable of forming deposits.

Very many of the nostrums that have from time to time been patented with this alleged object, have been incapable of any such action. They have often been educts of chemical or other manufactures, sought to be profitably got rid of, and not unfrequently of a character likely to be highly prejudicial to iron boilers. Thus soluble salts of arsenic and copper have been sold for this purpose. The chief agents that have been proposed with intelligent views, however, have been hydrochloric acid, more or less diluted; chloride of ammonia (sal ammonias), which constituted the matter of Ritterbandt's patent of 1850 or 1851; and chloride of calcium (an educt of many chemical manufactures). None of these are particularly effectual. Hydrochloric acid is a perilous addition to any iron boiler, as a very slight excess, when continued, will remove a large proportion of the thickness of the shell of the boiler in solution, as chloride of iron.

Sal ammoniac and other soluble chlorides are not free from this risk (for in presence of organic vegetable matter, iron is capable of decomposing slowly even common salt, and by a remarkable train of decomposition producing carbonate of soda, and evolution of free chlorine, which in turn re-acts upon the iron), and none of these agents have any advantageous action upon water rich in sulphate of lime.

Alkaline solutions, carbonate of soda, and caustic soda, have also been proposed, on the ground of their presence rendering the difficultly soluble salts of lime more soluble; but their action in this way is not marked, and the fact in practice is, that the alkaline water is carried up, more or less, with the steam into the pipes and engines, &c., and acts upon all flanches, joints, packings, paint, &c., as a destructive agent. Besides these, tan-pit liquor, decoction of oak bark, catechu, and various other astringent substances, have been strongly recommended by their several proposers; and perhaps strangest of all, dyewoods, and various vegetable coloring matters, constituted the sub-

ject of a patent of 1838,—of all of which we may safely say, that any other "chip in the porridge" would have been quite as useful.

Lastly, we arrive at the methods that have been proposed or adopted for mitigating or preventing deposit in marine boilers working with sea water.

In order of time, the first of these was the very primitive one of "blowing off," that is to say, that the sailing engineer, at stated intervals fixed by experience, permitted the feed pumps to work an excess of feed water into the boilers, and then blew off at the sea-cocks fixed into the bottom parts of the boilers, thus removing at such operation some of the muddy deposit of saline matter at the bottom cells of the boiler, and with it some of the denser and more concentrated brine. Occasionally the order of the process was reversed, the blowing off preceding the feed in excess of the average consumption of water in steam, but with the danger of laying bare some of the flue plates when the water was thus lowered. However, like every "rule of thumb" method, and in common with all dependent upon personal care and continuous attendance, this was often perilously neglected; and in my own early practice as a mechanical engineer, I have known the London steam ships come into the port of Dublin with every "pocket" or side chamber, beside the furnaces of their boilers, choked up with one solid mass of salt, that could only be removed by cutting the side plates out and replacing them.

The inventions of Hall and others for providing marine engines with surface condensation, and hence working with fresh water only, the same water being evaporated over and over again, had amongst other objects in view the relief of this great evil; and it is now highly probable that eventually this form of engine will be made fully available, and will displace the use of feeding with sea water.

They failed at first, however, and the invention and perfecting of the boiler-feeding arrangements known as the Brine Pump, and of the salinometer, displaced in all well provided steamships the old system of blowing off.

The brine pump is an adjunct of the feed pump, and its function is to remove at each stroke of the engine a determinate volume of the water, withdrawn from that part of the boiler supposed to be most highly concentrated as a saline solution, while the feed pump supplies in its place a larger determinate volume of sea water in its natural state. The cold sea water to be pumped into the boiler is caused to pass through tubes immersed in the boiling saline liquid, being pumped out by the brine pump, and robbing the latter of some of its heat, economizes part of the fuel that would be otherwise wasted.

The salinometer (one of the earliest promoters, if not proposers, of which was Mr. Scott Russell) is in fact an areometer or hydrometer, by which the specific gravity of the liquid within the boiler, and at various levels, may be tested. There are various constructions, some always presenting indications, more or less exact, of the density of the fluid actually within the boiler, others requiring a certain volume of the hot liquid to be drawn off for trial—all depend

upon the common principle of the areometer, the floating or not of bodies of known density immersed in the liquid, with adjuncts for correction as to temperature, &c.

The brine pump is often used without the salinometer—still oftener with it, but independently of its necessary control. But in the most complete arrangements the salinometer itself is contrived so as to regulate the proportion between the volume of water withdrawn and that needed to be supplied by the feed pump.

This was done on board the *Don Juan*, as an early example by the salinometer (in this case a large copper sphere, with considerable buoyancy) acting directly upon the valves of the brine pumps and feed pumps. A want of sufficient mechanical power for complete and trustworthy control was, however, I believe, always found; and a much better arrangement, although one that I am not aware has ever been before proposed or tried, would appear to be the adaptation to this use of Dr. Ure's thermostat—making the *temperature only* of the fluid in the boiler, or rather coming through the brine pump out of it, the rule as to saturation, and causing the powerful flexure of the thermostat bars (which may be quite immersed within the boiler or its pipes) to act directly upon the valves regulating the supply.

It scarcely needs pointing out that no chemical, or other agents introducible to marine boilers, are capable of producing the slightest practical effect upon the enormous volume of water evaporated, and of saline matter in a state of deposit.

If the boiler contains 100 parts of sea water, and the parts evaporated for steam in a given time be $= s$, and if n be $=$ the volume pumped out in order to preserve the state of saline concentration constant at a, $=$ (a fraction) parts of solid saline matter, then, as there is 3 per cent. of saline matter in sea water (in round numbers)—when

$$3\,(s + n) = a\,n.$$

The amount of saline matter entering the boiler by the feed pump and removed by the brine pump will be equal; and in this case the brine pump must remove

$$n = \frac{3 \cdot s}{a - 3} \text{ volumes.}$$

If $a = 30$, which is the saturated point for common salt — one-ninth of the feed water must be removed by the brine pump, and as $\frac{1^n}{6}$, the fuel that will convert water into steam from a given temperature, will bring it to 212°, the loss of fuel by this inward influx of cold water to the boiler, and removal of boiling water, will be—

$$\frac{1^n}{6} + \frac{1^n}{9} = \frac{1^n}{54} \text{ of the whole quantity.}$$

assuming that none of the heat were returned to the boiler by conduction, between the issuing and entering fluids, as explained.

This somewhat crude view of this part of our subject will serve to illustrate the main question, to the more complete solution of which M. Couste's Memoir is dedicated.

—

In concluding this paper we may notice the improved salinometer of Long, which is much used in the steamships of the United States.

These instruments possess many advantages over those hitherto used.

They are *constantly in action*, and the density of the water may at any moment be read off; while the engineer *cannot be scalded, nor the hygrometer broken*, as is so often the case with the ordinary instrument.

The Committee of the Franklin Institute advise the "more general use of this valuable gauge, which ought not to be neglected on any boilers using salt water, and they commend it to the notice of all engaged in the management of such boilers." By its use a great saving of boiler and fuel is effected. See *Journal of Franklin Institute*, February, 1860, page 141.

On Bessemer's Iron and Steel.

From the London Mechanic's Magazine, Sept., 1862.

Among the treasures of the Eastern Transept it would be unfair to omit noticing one of the most conspicuous, and, in some senses, one of the most important, trophies, namely, that of Mr. Bessemer. The taste which induced that gentleman to select as the medium for exhibiting specimens of his iron and steel, a polished mahogany stand, more in keeping with the fitments of a modern gin palace than appropriate to the use to which it is applied, may be questioned; but there can be no question about the value of the materials which the stand serves to display. In every variety of form, and in every process of its manufacture, the Bessemer iron and steel are shown in the Eastern Transept, and there adaptability to innumerable purposes is developed. It is not necessary here to enumerate the articles exhibited, nor to enter into the particulars of the remarkable and yet simple processes by which the conversion of crude iron into steel of the Bessemer kind is effected. It may be stated, nevertheless, that many and severe were the testings to which the substance was exposed, before it was admitted into the favor of those who were predisposed to the use of steel produced by the old, and time-honored system. The extreme toughness of the Bessemer iron was proved by the bending of a cold bar of 3 ins. square, under the hammer, and into a close fold, without the smallest perceptible rupture of the metal at any part; and the bar was thus extended on the outside of the bend from 12 ins. to 16¾ ins., and was pressed on the inside from 12 ins. to 7¼ ins., thus showing a difference in length of 9½ ins. between what, before bending, were the two parallel sides of a bar 3 ins. square. Again, an iron cable, consisting of four strands of round iron 1½ ins. in diameter, was, while cold, so closely twisted as to cause the strands at the point of contact to be-

come permanently embedded into each other. Each of these strands had become elongated to 12½ ins. in a length of 4 ft., and had diminished one-tenth of an inch in diameter throughout their whole length.

Steel bars, of 2 ins. square and 2 ft. 6 ins. in length, were twisted cold into a spiral, the angles of which were about 45°; and some round bars, 2 ins. in diameter, were bent cold under the hammer, into the form of an ordinary horse-shoe magnet, the outside of the bend measuring 5 ins. more than the inside. The steel and iron boiler plates, left without shearing, and with their ends bent over cold, afforded ample evidence, too, of the extreme tenacity and toughness of the metal; while the clear, even surface of railway axles and pieces of malleable iron ordnance, were examples of the perfect freedom from cracks, flaws, or hard veins. The tensile strength of this metal was not less remarkable. The several samples of steel tested in the Proving Machine at Woolwich Arsenal bore, according to the reports of Colonel Eardley Wilmot, R. A., a strain varying from 150,000 lbs. to 160,900 lbs. on the square inch. Four samples of iron boiler-plate similarly tested, bore from 68,314 lbs. to 73,100 lbs.; while, according to the published experiments of Mr. W. Fairbairn, Staffordshire plates bore only 45,000 lbs., and Low Moor and Bowling plates a mean of 57,120 lbs. per square inch. Of course, the cost of production of the materials was considerably less than that of the plates put into competition with Mr. Bessemer's; and here another advantage of no slight consequence is evident.

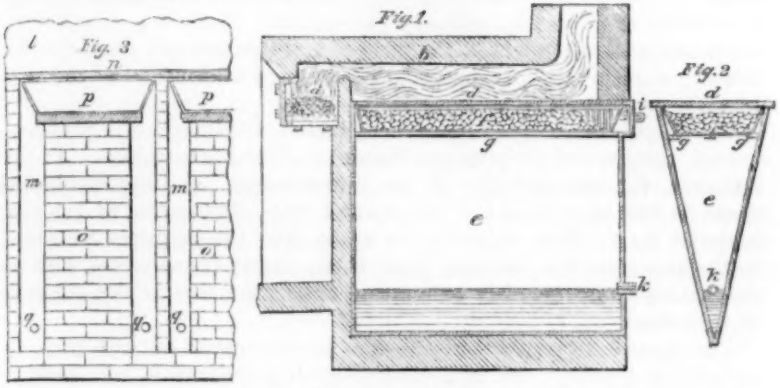
Specification of a patent granted to WILLIAM MATTIEU WILLIAMS, *for an improvement in treating coal and other bituminous minerals and peat, in order to obtain solid and liquid hydro-carbons therefrom, and in apparatus to be used for that purpose.*—(Patent dated 21st December, 1861.)

From Newton's London Journal of Arts, September 1862.

The object of this invention is so to treat coal and other bituminous minerals, and peat, by the distillatory process, as to increase the solid and liquid or more valuable products, in proportion to the gaseous or less valuable products. In the distillation of coal, it is found that the gaseous products of the distillation are mainly or largely produced by the decomposition of the vapors of the solid and liquid products; the decomposition being affected by such vapors coming in contact with portions of the retort or its contents, heated to a higher temperature than that at which the vapors are liberated from the coal. By conducting the distillation in the manner and by means of the apparatus hereafter described, the overheating of the condensible products, first volatilized from the coal, is prevented, and thereby a larger yield of the condensible products is secured.

The apparatus used for treating coal and other bituminous minerals, and peat, in order to obtain solid and liquid hydro-carbons therefrom, is shown in diagram; fig. 1 being a vertical longitudinal section of the retort, set in a reverberatory furnace, and fig. 2 a cross vertical

section. The flame and products of combustion from the fire in the fire-place *a*, pass along the reverberatory arch *b*, into the chimney or flue *c*. The heat is reverberated downwards upon the bed *d*, of the furnace, which bed *d*, constitutes the top of the retort *e*, or a casing immediately above the top of the retort. The lower part of the retort *e*, tapers or contracts, as seen in fig. 2. Where the vessel is short, it is made taper on all sides—that is, it is made of the figure of an inverted cone or pyramid, but when much longer than it is broad, the tapering is confined to the inclination of the two longer sides, as represented in figs. 1 and 2.



The coal or other matter to be treated is placed in the cage or tray *f*, which rests upon the projections *g*. The sides of the tray *f*, are perforated, or are made of bars. The trays may be introduced into, and withdrawn out of, the distillatory vessel *e*, in a horizontal direction, at an opening in the side of the vessel at *h*, which opening is closed after the introduction of the charge, by means of a door *i*. The plate *d*, which constitutes the bed of the furnace and the top of the distillatory vessel, may be protected from injury by the fire, by a layer of thin fire-tiles or powdered clay or sand, or a mixture of clay and sand. The fire of the furnace *a*, plays upon and heats the top of the vessel *e*, and the heat from the heated top radiates downwards upon the contents of the tray *f*, and liberates volatile hydro-carbons therefrom. The vapors produced pass out between the bars constituting the sides of the tray *f*, or through perforations in its sides and bottom, and descend to the lower part of the distillatory vessel, from which the condensed and uncondensed portions pass by a pipe *k*, fixed nearly at the bottom of the vessel *e*. A small quantity of water, which is formed or volatilized with the hydro-carbons, condenses and occupies the bottom of the vessel *e*, and may be let off by a stop-cock fixed at the lowest point of the vessel *e*.

In carrying this invention into effect on a large scale, several retorts or distillatory vessels are employed, arranged side by side in the same furnace. In this case, the retorts are placed across the reverberatory arch of the furnace, as represented in the vertical section, fig. 3, which

is taken along the middle of the reverberatory arch *l*. Each of the retorts or distillatory vessels consists of a chamber *m*, the sides and bottom of which may be made of iron or of brickwork. The top of the chambers consists of a plate, or series of plates, of cast or wrought iron *n*, on which the heat of the furnace is reverberated by the reverberatory arch or flue *l*. In the middle of each retort or distillatory vessel is a wall or support of brickwork *o*, running from end to end of the vessel. The said walls or supports *o*, in each vessel, support the trays *p*, containing the material to be operated upon. The trays are introduced into the retorts *m*, at openings at the end of the vessels, similar to the openings hereinbefore described and represented in fig. 1, or those employed in ordinary gas retorts. Pipes at *q*, conduct the condensed and uncondensed products of distillation away from the distillatory vessels into a receptacle, where the condensation of the condensible products may be completed.

The distillation may either be conducted at atmospheric pressure, or at a greater or less pressure than that of the atmosphere. In the first case, the terminal pipe of the retort is open, and the condensed products run therefrom. In the second case, the bottom of the pipe is closed by a valve, weighted, so as to give the required pressure. In the last case, the terminal pipe of the retort is connected with an exhausting pump or other exhausting apparatus, worked by steam or other power.

The patentee claims, "First,—the improvement hereinbefore described, in treating coal and other bituminous minerals, and peat, in order to obtain solid and liquid hydro-carbons therefrom—that is to say, subjecting these substances to a distillatory process so conducted that the volatile products produced pass rapidly downwards from the heated part of the apparatus, so as not again to be exposed to a temperature equal to that at which they were produced. Secondly,—the improvement in apparatus for treating coal and other bituminous minerals, and peat, in order to obtain solid and liquid hydro-carbons therefrom, hereinbefore described and illustrated—that is to say, constructing and arranging the retorts or distillatory vessels so that heat is applied at the top of the said vessels, and the volatile products conducted, by a descending motion, from the heated parts of the said apparatus."

Improvement in Tanning.

The fresh bark is to be ground and introduced into a cask; a quantity of water sufficient to cover it is introduced, and the cask is then closed hermetically to prevent the action of the atmospheric air. It is suffered to remain for some weeks in order to allow the soluble matters to dissolve, and is then filtered to free it from the refuse bark. This liquid, when exposed to a gentle heat, enters into alcoholic fermentation, and will mark 1° or 2° on the alcoholometer. If a skin be introduced into this solution, it tans very quickly, but becomes hard and horny because the liquid is too much concentrat-

ed. If on the contrary it be diluted with water, excellent results are obtained. The hides thus tanned are more pliable and the grain is closer than in those tanned by the common method. The same quantity of bark, moreover, produces more tanning material, in this new method.

The bark should not be boiled with the water; for the boiling coagulates the albumenoid matters, which excite the fermentation. The author has satisfied himself by trial, that the liquid which has undergone only the alcoholic fermentation gives better results than that which has become acid. *Cosmos.*

On the Exhalations from Wood.

From the London Builder, No. 1018.

Everything in London continues to assume more and more gigantic proportions. The quantity of lucifer matches for one day's metropolitan consumption has often excited surprise: it is daily on the increase, as is also the quantity of firewood, which is enormous. Besides the parts of decayed merchant vessels, and other battered "old hulks;" the timbers and boards of demolished buildings which cannot be again worked into new ones, the salvage from fires, &c.; there are immense quantities of pine wood brought from over the sea as mere firewood. It is cut into pieces of about 3 feet in length, and of convenient thickness; so that, by means of steam-sawing machinery, they can readily be cut into the usual length of the bundles of firewood sold in the shops: they are then chopped, sorted, and tied up by boys, ready for sale.

During the summer months, the planks of wood, as they are unshipped, are brought in barges to convenient wharfs along the margin of the canals; and are stacked until needed for use. Some of these collections of firewood are cleverly built up, and are of gigantic proportions: one or two of these may be seen in the wharf of Mr. Humphries, in the York-road: one stack is at least 50 feet high, and is ingeniously constructed, so that the chief bulk of the materials is sheltered from the weather, and allowed to dry. The *architect* of this wooden work, with an eye towards effect, has caused it to assume something of the appearance of a military fortress, by leaving holes for imitation cannon, which point in a threatening manner towards the road. The building up of these towers, as barge after barge-load of timber arrives, gives employment to a large number of youths and boys; and, during the whole year, the chopping and preparation of the firewood—not only here, but also in other parts of London—keeps busy some hundreds of boys, many of them connected with the reformatory and other schools.

The manufacturing of the patent firewood—an invention by which the wood is cut into very small pieces, and joined together in a circular form by means of resin—is chiefly managed by boys; and it is astonishing to see the rapidity with which the process is carried forward by the nimble fingers and the machinery employed on the mate-

rial, and the quantities of this prepared firewood which are constantly passed into the London market.

There are other large stores of wood for building and other purposes along the sides of the canal; and, as space is valuable, these also are built up to a great height, and the planks are so arranged that they are but little exposed to the wet, while the air is allowed to ventilate through all parts.

We have just now more particularly mentioned these collections of timber for the purpose of directing attention to a peculiarity connected with them. Often, in certain neighborhoods, especially if the place be closely confined, the writer has noticed a smell which he had attributed to imperfect drainage; but finding, in one or two instances, that there were no derangements of this kind to be complained of, he looked for other reasons, and found that there were stores, either greater or smaller, of green and other wood, in the localities where this peculiar smell was to be met with; and he has since found that from these collections of wood a considerable quantity of gas is thrown off, which pervades the atmosphere to some distance around. We do not say anything just now about the unwholesomeness of this, but simply mention the fact, so that it may explain a circumstance which might otherwise puzzle the sanitary inquirer.

Electric-Express.

M. Bonelli, the re-inventor of Bain's (Bakewell's) copying telegraph, suggests a new application of electricity for the transmission of letters, light parcels, &c. A series of coils of insulated wire are adjusted along the route, and through them runs a pair of rails upon which travels the wagon which carries the despatch-box. This wagon also carries an electric battery, and the end of the coils are so adjusted that the battery connexion is made, by means of the wheels and rails, through the coil which it is just about to enter. As the wagon is of sheet-iron, it will be attracted to the centre of the coil, and the momentum which it acquires will carry it far enough to make the connexion through the next coil, when the impulse is renewed.

This contrivance will make a very pretty philosophical toy, or piece of illustrative apparatus; but can it be economically applied on a practical scale? *Cosmos.*

Ventilators or Valves.

From the London Builder, No. 1020.

Letters patent have been taken out by Mr. Neil McHaffie, 16 Summer-street, Mile-end, Glasgow, for the invention of "improvements in ventilators or valves for regulating the passage of air or other fluids, whether of a gaseous or liquid form." The specification thus describes Mr. McHaffie's invention:—"According to my invention, when applying a ventilator or valve for admission of external air, I

cause the current of air entering to impinge on a surface so arranged that, when the current of air exceeds the velocity considered desirable, the surface may be able to yield to it, and on yielding may close or partially close the valve. When the force of the current diminishes the valve again opens, it being so weighted as always to tend to do so. The arrangement I prefer consists of an inlet valve turning on an axis at the centre of its width. This valve is connected by a suitable connecting-rod to a surface mounted on a horizontal axis at or near its lower end. The said surface is weighted beneath the axis, so that it tends always to assume a vertical position. It is placed at a short distance from the before-mentioned valve, within a trunk or passage, which obliges the air or other fluid entering by the said valve to pass the before-mentioned surface. This current of air or other fluid throws the surface into a more or less inclined position, according to its strength; and the more inclined the position of the surface, the more nearly will the valve be closed. For the passage of liquids this last-mentioned surface should be mounted on a horizontal axis; but instead of being at or near its lower, it should be at or near its upper extremity, on account of the greater density of the fluid, the passage of which is sought to be regulated."

Texture of Copper.

M. U. Vivian showed last year that manufactured copper always has a porous and cellular texture; whilst native copper is always crystalline. Now he proves that the native copper from Lake Superior is neither crystalline nor cellular, but dense, ductile, and fibrous, as though it had been violently compressed when cold. When melted it however takes the structure of all manufactured copper.—*Cosmos.*

Experiments on Steel Wire-Rope.

From the Lond. Mining Journal, No. 1419.

At the Liverpool Corporation Testing-Works, on Tuesday, a number of gentlemen interested in the subject assembled for ascertaining the superiority, if any, of steel wire-rope, as compared with iron wire-rope. Experiments had been previously made upon bright steel wire, which, being liable to rust, it was now thought desirable to know if the strength would in any degree be impaired by the wire undergoing the process of galvanizing; and it was chiefly for this reason the experiments were made, the samples being ropes made of steel wire galvanized. The results obtained were—Galvanized steel, 2 in., broke at 13 tons 15 cwts.; Admiralty test for iron wire, 4 tons 6 cwts.; galvanized steel, 2½ in., broke at 19 tons 10 cwts.; iron wire, Admiralty test, 7 tons 8 cwts.; galvanized steel, 4 in., broke at 41 tons 5 cwts.; iron wire, Admiralty test, 19 tons 6 cwts. Two pieces of 2½ in., of fine bright steel, similar to that used for musical instruments, broke, one at 24 tons 5 cwts., the other at 26 tons 5 cwts. Thus, by the confirmation of two separate tests, we are assured that steel possesses

all the qualities suitable for its being used for all purposes, whether in mines or elsewhere, where great strength is required. Indeed, for strength, lightness, toughness, and elasticity, it is unsurpassed, and it is calculated that while the expense is little more than that of common iron, by the substitution of steel Messrs. Garnock, Bibby and Co. will be enabled to save about 4 tons in the weight of the rigging of a single ship.

New Method of Organic Analysis. By M. Maumené.

In our present processes of organic analysis, there is no direct means of determining the quantity of oxygen, this important element being estimated simply by the loss, or difference between the sum of the weights of the other elements computed, and the original weight of the body—of course every error committed in the estimation of the carbon, hydrogen, and nitrogen is accumulated upon the determination of the oxygen. Hence, in great part, the want of agreement as to the percentage of this substance among analysts. M. Maumené proposes to determine the oxygen by using the oxide of lead or litharge mixed with one-quarter of its weight of phosphate of lime to prevent it from fusing. We then obtain, by the reduction of the litharge, a button of metallic lead which may be accurately weighed. This gives us a third equation of the analysis, viz: *Carbon* $= \frac{3}{11}$ of the carbonic acid; *Hydrogen* $= \frac{1}{9}$ water; Oxygen $= \frac{8}{9}$ water $+ \frac{8}{11}$ carbonic acid $- \frac{8}{103{\cdot}5}$ lead, and the values determined from these three equations must satisfy the original equation. *Weight used* = Carbon + Hydrogen + Oxygen. *Acad. Sciences, Paris*, Sept., 1862.

Testing the purity of the Atmosphere.

From the London Builder, No. 1029.

Dr. Angus Smith has shown, by his process of testing the purity of the atmosphere, that a given amount of permanganate solution is decomposed by different volumes of air, according to its state of purity. The numbers below given show the volume of air capable of decomposing an amount of the solution of the permanganate,—the same in every case. The figures, therefore, represent the proportionate purity of the air. The highest numbers represent the purest.

Manchester.

	Cubic Inches.
Air at All-Saints, inside my laboratory,	72,000
Front of the house,	74,000 to 76,000
Bed-room, looking to the back,	64,000
Same room in the morning, after having been slept in,	56,000
Bank of the Medlock, behind dirty houses,	44,000
High ground, thirty miles from Manchester,	176,000 to 209,000
Closely-packed railway-carriage,	8,000
When the strong smell of a sewer entered my laboratory,	8,000

On a Green Color which may be Employed in Confectionery.

From the London Chemical News, No. 142.

The finest green color is formed, as is known, from preparations of copper and arsenic; that of which the formula is here given is devoid of danger, and may replace it. To obtain it, infuse for twenty-four hours 0·32 grammes of saffron in 7 grammes of distilled water. Then take 0·26 grammes of carmine of indigo, and infuse it in the same manner in 15·6 grammes of distilled water. Then mix the two liquids together, and a very beautiful green color is obtained, which may be employed for coloring an immense quantity of sweetmeats (10 parts of this solution will color 1000 parts of sugar of a very beautiful green). This color may be preserved for a long time, either by evaporating the liquid to dryness or by converting it into a syrup.—*Journal de Pharmacie et de Chimie*, xli. 286.

Glass Blowing.

A Belgian glass-blower, M. Emile Lefevre-Moran, attached to the glass-works of Lefevre & Co., at Lodelingart, has just blown two bottles containing each 62½ gallons and weighing 50 pounds. The largest heretofore blown did not contain more than 32½ gallons.—*Cosmos.*

Parkesine.

From the Lond. Chemical News, No. 140.

A number of pretty and useful articles, formed of a material which the inventor, Mr. Parkes, has named after himself, are exhibited in Case 1112, Class IV. The basis of this material is the mixture of collodion and castor oil, with which our medical and pharmaceutical readers are well acquainted. With this compound the inventor mixes coloring-matters, resins, gums, and earthy matters, according as he wishes, for a plastic, flexible, or hard material, out of which to form medallions, combs, or knife-handles, and the like. The specimens exhibited look pretty as well as useful, and are no doubt durable as long as they are kept out of the fire. A wide field is open for applications of the substance, and Mr. Parkes should get it into the market, and ascertain how far it can compete with similar articles having india-rubber for their basis.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, Dec. 18, 1862.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society and the Institute of Actuaries, London, and the Literary and Philosophical Society, Manchester, England; Thomas Oldham,

LL.D., Superintendent of the Geological Survey of India, Calcutta, India; from Hon. Wm. D. Kelley, Frederick Emmerick, Esq., and the Agricultural Department, Washington, D. C.; S. Stockton White, Esq., Prof. John F. Frazer, Prof. John C. Cresson, Captain S. W. Dewey, and the American Philosophical Society, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of November was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (9) were proposed, and the candidates (15) proposed at the last meeting were duly elected.

Nominations were made for Officers, Managers, and Auditors of the Institute for the ensuing year.

Mr. Thomas Stewart exhibited an Anti-friction Valve patented by him, and stated that the object of the invention is to obtain an Anti-friction Valve that will not require attention to keep it in working order, nor that precision of adjustment which balanced valves require—the steam operating on the mechanism performs this office with unerring precision.

To accomplish this object, the inventor uses the following arrangement:—First, the ordinary slide valve is made with the back planed true with the face; on this there is a frame made to work steam-tight, covering a part of the valve equal to the area of the ports in the valve-seat; on the other side of this frame there is secured, steam-tight, a flexible diaphragm, which shuts the steam off from the inside of the frame, relieving the valve of so much of the pressure of the steam; the pressure now being exerted on the diaphragm, so much of the centre of the diaphragm as is equal to the area of the frame in contact with the valve, is suspended to a cross-piece resting on two projections on the sides of the steam chest, thus relieving the valve of all unnecessary pressure; at the same time the flexibility of the diaphragm allows the balance frame, by a very slight pressure of steam, to keep the frame in close steam-tight contact with the valve, and also allow the valve to move freely under it.

Mr. Thomas Shaw exhibited a valve designed by him and patented August 9th, 1862. It is intended to relieve feed pumps of the air or vapor that accumulates whilst they are not working. It consists of a chamber containing a thin gum-valve closing upon a metal seat and opening outward. A stop-cock is interposed between this valve and the pump to close the communication after the air or vapor is expelled, and prevent the escape of the water.

Mr. John Sloan exhibited a number of inside soles for shoes, intended to keep moisture from contact with the feet. They are composed of two thicknesses of wood, with a thin metal plate of brass between, the whole united by eyelets, which also serve for circulation of air.

A Comparison of some of the Meteorological Phenomena of Nov., 1862, *with those of* Nov., 1861, *and of the same month for* TWELVE *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By JAMES A. KIRKPATRICK, A.M.

	November, 1862.	November, 1861.	November, 12 Years.
Thermometer—Highest degree, .	71·00°	63 50°	80·0°
" " date, .	2d	3d.	1st, 1860.
" Warmest day—Mean,	61·67	58·70	72·30
" " " date,	2d	2d.	9th, 1857.
" Lowest degree, .	27·00	29·00	16·00
" " date, .	7th and 8th.	25th.	25th, 1860.
" Coldest day—Mean,	30·50	35·50	23 30
" " " date,	7th.	25th.	25th, 1860.
" Mean daily oscillation,	13·40	13·08	13·38
" " " range,	5·94	4·11	5·65
" Means at 7 A. M., .	40·67	39·85	41·06
" " 2 P. M.,	48·18	48·73	50·18
" " 9 P. M., .	43·25	43·25	44·25
" " for the Month,	44·03	43·94	45·16
Barometer—Highest—Inches, .	30 555 in.	30·109 in.	30·661 in.
" " date, .	16th.	1st.	12th, 1851.
" Greatest mean daily press.,	30·509	30·075	30·520
" " date, .	16th.	1st.	12th, 1851.
" Lowest—Inches, .	29 380	29·213	29·117
" " date, .	20th.	6th.	19th, 1857.
" Least mean daily pressure,	29·467	29·359	29 255
" " date, .	20th.	6th.	19th, 1857.
" Mean daily range, .	·159	·179	·184
" Means at 7 A. M., .	29·877	29·793	29·918
" " 2 P. M., .	29·823	29·736	29·877
" " 9 P. M., .	29·870	29·785	29·905
" " for the Month,	29·857	29 771	29·900
Force of Vapor—Greatest—Inches,	·548 in	·523 in.	·832 in.
" " " date, .	20th.	2d.	8th, 1857.
" " Least—Inches,	·106	·099	·055
" " " date, .	16th.	19th	25th, 1857.
" " Means at 7 A. M.,	·213	·199	·227
" " " 2 P. M.,	.228	·210	·231
" " " 9 P. M.,	·224	·206	·234
" " " for the month,	·222	·205	·231
Relative Humidity—Greatest per cent.,	100· per ct.	96·0 per ct.	100· per ct.
" " " date, .	7th.	23d.	6th, '52; 21st, '56.
" " Least per cent,	37·	32·0	26·0
" " " date, .	13th.	19th.	27th, 1857.
" " Means at 7 A. M.,	79·4	78·2	77·8
" " " 2 P. M.,	64·5	58·1	59·5
" " " 9 P. M.,	75·1	70·5	74·2
" " " for the month,	73·0	68·9	70·5
Clouds—Number of Clear days,* .	8	9	8·7
" " Cloudy days,	22	21	21·3
" Means of sky cov'd at 7 A. M.,	64 per ct.	51·7 per ct.	60·1 per ct
" " " " 2 P. M.,	64·3	66·7	60 5
" " " " 9 P. M.,	63·7	52·3	52 6
" " " for the month,	64·0	56·9	57·7
Rain and melted Snow—Amount .	4·455 in.	4·613 in.	3·822 in.
No. of days on which Rain or Snow fell,	15·	11·	10·8
Prevailing Winds, . .	s79°0′ w. ·237	s68°12′w.·324	s.67°43′w·254

* Less than one-third covered at the hours of observation.